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Bell Telephone MAGAZINE

The Bell System's Interest in Program Television • KEITH S. MCHUGH and GEORGE L. BEST

A Review of Army and Navy Communication Facilities • MYRON F. DULL

The Telephone Remakes Naval Warfare • FLETCHER PRATT

A Bridge for Speech across Chesapeake Bay • AUSTIN BAILEY

A Century of Electrical Communication • ROBERTSON T. BARRETT

Radio Telephones Guide the "Blitz Buggies" • VANCE HILLIARD

American Telephone & Telegraph Company · New York

Bell Telephone Magazine

Spring 1944

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"The ideal and aim of the American Telephone and Telegraph Company and its Associated Companies is a telephone service for the nation, free, so far as humanly possible, from imperfections, errors, or delays, and enabling anyone anywhere to pick up a telephone and talk to anyone else anywhere else, clearly, quickly and at a reasonable cost."

A Medium of Suggestion & a Record of Progress

Published for the supervisory forces of the Bell System by the Information Department of AMERICAN TELEPHONE AND TELEGRAPH COMPANY, *195 Broadway, New York, N. Y.*

Who's Who & What's What

in This Issue

EMPLOYED as a clerk by the A. T. & T. Co. in 1919, elected a vice president of the same company in 1938: that is KEITH MCHUGH'S up-the-ladder record. Chronologically a straight ascent, geographically it included stop-overs in Washington, D. C., with the Chesapeake and Potomac Telephone Company, and in Albany, Brooklyn, and Manhattan with the New York Telephone Company. *En route,* Mr. McHugh held positions as general commercial engineer, general commercial manager, and vice president with those companies; and was commercial engineer and assistant vice president with A. T. & T. before reaching his present post. In it he has to—and does—take always the broad view. His article shows how that can be the long view too. "War Activities of the Bell Telephone System," in the issue for November, 1942, was his previous contribution to this MAGAZINE.

THE CONSERVATIVE STREAK in GEORGE BEST'S make-up is no surprise to those who know that he was born, "raised up," and educated in Vermont. Once away from that green-hilled state, he joined the New York Telephone Company in 1922, and held successive positions in the commercial department there for the next 15 years. In 1937 he was transferred to the commercial division of A. T. & T., and was rate engineer and commercial engineer before becoming, in 1942, an assistant vice president on Mr. McHugh's staff.

METHODS OF military communication have changed so radically since the last World War that the relation between MYRON DULL'S service with the Signal Corps in 1918–19 and his present assignment is probably, as publishers say, "purely coincidental." His 27 years with the Bell System have brought him plenty of qualifications, in any event, to carry on the work which he describes. They include experience as district manager at Newcastle and general directory manager and general sales manager for the western area of the Bell Telephone Company of Pennsylvania; and since 1929 with A. T. & T. Company's Depart-

KEITH S. MCHUGH

GEORGE L. BEST

MYRON F. DULL

FLETCHER PRATT

AUSTIN BAILEY

ROBERTSON T. BARRETT

ment of Operation and Engineering in charge of groups concerned with customer servicing and with toll and teletypewriter development. Washington has been his base for the past year and a half, so by now he can really find his way through the mazes of the Pentagon, where he has his office.

FOR EXPERT OPINION about how radio telephony is affecting the strategy and tactics of our battle fleets, the editors turned to FLETCHER PRATT, whose article makes encouraging reading for anyone (except our enemies) and gratifying reading for all those who have had anything to do with the development or manufacture or application of that kind of equipment. Mr. Pratt is well known as a student of and writer on naval subjects. He does a syndicated daily newspaper column on current events and military affairs; a series of his articles has been appearing in *Harper's Magazine;* and he is the author of a number of books, including "The Navy: A History," "Secret and Urgent: The Story of Codes and Ciphers," "The Navy Has Wings," and others. Membership in the U. S. Naval Institute attests to the competence of his judgment on matters nautical.

THE AVERAGE LAYMAN should find the application of carrier techniques to radio transmission less of a mystery after reading AUSTIN BAILEY'S explanation of how a dozen voices can be carried at one time across the mouth of Chesapeake Bay. Before joining the Bell System in 1922 he had acquired both A.B. and Ph.D. degrees, and experience in the Signal Corps in the last World War, in private industry, and as a college professor. Since then he has been a member of the Departments of Development and Research and Operation and Engineering of the A. T. & T. Co., and of the Bell Telephone Laboratories, and spent a year in England and Scotland in connection with establishing the first commercial transatlantic radio telephone circuit. He is regularly concerned with the technical aspects of numerous radio projects. He has contributed several articles to this MAGAZINE, the most recent, in the issue for November, 1942, being "Bridging Breaks in Wire Circuits by Radio Telephone."

THE POST of Historical Librarian of the A. T. & T. Co. provides background information for ROBERTSON T. BARRETT'S "A Century of Electrical Communication." Practice of the law and of journalism successively engaged him before he joined the Information Department in 1921. As a member of the departmental staff, he has contributed more articles to this publication and its predecessor, the *Bell Telephone Quarterly,* than any other person; most

(*Continued on page 62*)

The Board of Directors of the American Telephone and Telegraph Company

AT THE ANNUAL MEETING of stockholders of the American Telephone and Telegraph Company held on April 19, the directors then in office were re-elected. The picture on the opposite page, taken at the March meeting of the Board, shows all members in attendance. Beginning with Mr. Gifford, at the head of the table in the foreground, and reading clock-wise, they are:

WALTER S. GIFFORD. President, American Telephone and Telegraph Company.

JOHN W. DAVIS. Attorney; Member of Firm of Davis Polk Wardwell Sunderland & Kiendl, New York, N. Y.

CHARLES P. COOPER. Vice President, American Telephone and Telegraph Company.

SAMUEL A. WELLDON. Vice President, The First National Bank of the City of New York.

ARTHUR W. PAGE. Vice President, American Telephone and Telegraph Company.

W. CAMERON FORBES. Partner, J. M. Forbes and Company, Merchants, Boston, Mass.

G. PEABODY GARDNER. Trustee.

TOM K. SMITH. President, The Boatmen's National Bank of St. Louis.

THOMAS I. PARKINSON. President, The Equitable Life Assurance Society of the United States.

ISAIAH BOWMAN. President, Johns Hopkins University.

LEWIS H. BROWN. President, Johns-Manville Corporation.

DAVID A. CRAWFORD. President, The Pullman Company.

ELIHU ROOT, JR. Attorney; Member of Firm of Root, Clark, Buckner & Ballantine, New York, N. Y.

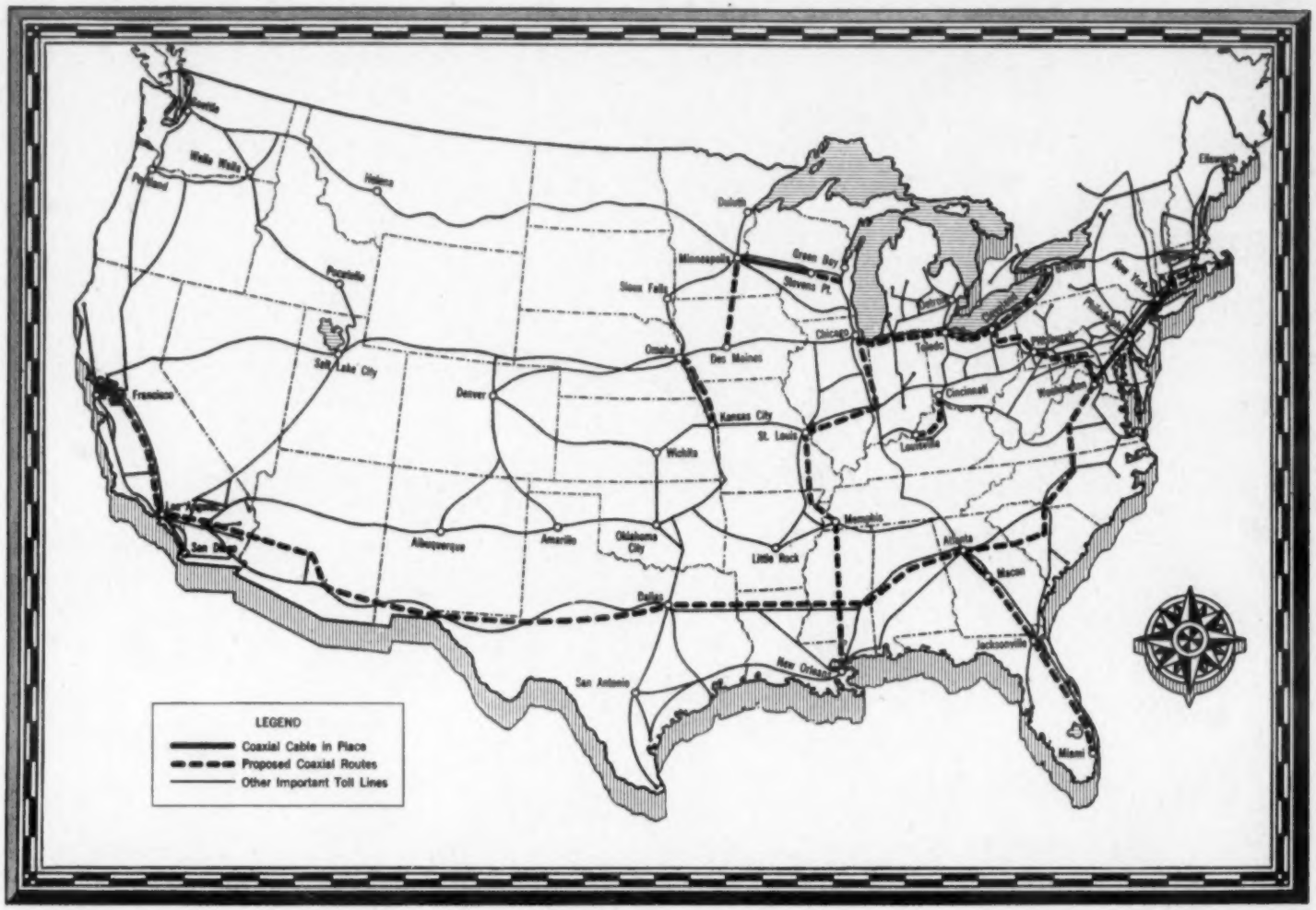
S. CLAY WILLIAMS. Chairman of the Board, R. J. Reynolds Tobacco Company.

JAMES F. BELL. Chairman of the Board, General Mills, Inc.

WINTHROP W. ALDRICH. Chairman of the Board, The Chase National Bank of the City of New York.

MYRON C. TAYLOR. Attorney.

CHARLES FRANCIS ADAMS. Chairman of the Board, State Street Trust Company of Boston.



BELL SYSTEM COAXIAL ROUTES

The Expansion of the Coaxial Cable Network to Several Thousand Route Miles by 1950 Holds Great Possibilities for the Transmission of Television Programs

The Bell System's Interest in Program Television

Keith S. McHugh and George L. Best

THE POSSIBILITIES OF TELEVISION in the field of entertainment and education have captured the imagination of a great many people, both in this country and in other countries. While its development is temporarily retarded by the war, there is every indication that a new industry, perhaps rivaling in scope the present sound broadcasting industry, is in the making.

There are now broadcasting stations in New York, Philadelphia, Schenectady, Chicago, and Hollywood presenting regularly-scheduled television programs for a few hours each week. The owners of these stations are planning to extend and improve their programs as rapidly as they can. Plans are also being made to establish new television broadcasting stations, following the war, in many other cities throughout the country.

Manufacturers of radio receiving sets are engaged in developing ways of making television receivers which can be sold at prices within the range of the average person. Sales promotion programs are being prepared to distribute these sets as rapidly as they can be put on the market.

Motion picture and theater people are considering the possibilities of large screen television in theaters to bring news events of especial interest to their audiences as they happen. They are also studying its possibilities as a means of offering various forms of entertainment, including prize fights, football games, track meets, etc. Schools and colleges are beginning to think about television as an aid to education.

While a great deal remains to be done, technically and otherwise, before television comes into common use, the present and proposed widespread activity in this field raises the question as to what part the Bell System is playing in the development of this new industry.

The Need for Network Transmission Facilities

UP TO NOW, television programs have been confined largely to local events of interest, local studio programs, and sound films. While considerable use may continue to be made of this type of program material, television will not reach its ultimate usefulness until it is possible to bring programs from distant points to a number of cities at the same time. It is in the provision of network facilities by which broadcasting stations and others can be connected that we believe the Bell System's primary part in program television will be played, just as it has been in sound broadcasting. That this rôle is one of great importance to the development of television is evident.

Television transmission consists of sending from the point of origin of the program to the receiving apparatus at the distant point a complete description of about thirty different visual images per second. This is done in effect by dividing each image into 200,000 or more different parts and sending a signal to the distant point indicating the density or degree of brightness of each part, together with its position in relation to other parts of the image. The receiving apparatus then translates these signals into a motion picture. The transmission of television, therefore, requires facilities capable of transmitting six million or more different signals per second.

The types of circuit facilities required to transmit television signals in the required quantity and speed are closely related to those needed for the transmission of large numbers of telephone or telegraph messages simultaneously. Coaxial cable is designed to carry large numbers of telephone conversations simultaneously over a single pair of conductors and, if properly equipped for such use, is also suitable for transmitting television.

Coaxial cable, in the form now being used by the Bell System, is the result of years of research and development work in the Bell Telephone Laboratories. The first commercial trial of coaxial cable for telephone use in this country was made between New York and Philadelphia in 1936. Its use for transmitting visual images for television broadcasts was first demonstrated in 1937.

Since that time, coaxial cable has been installed between Minneapolis and Stevens Point, Wisconsin, and between Philadelphia and Washington. A coaxial cable route between Atlanta and Jacksonville is now under construction.

AS A PART of its program to meet expected increasing demands for long distance telephone service, the Bell System is planning to construct within the next few years a large amount of additional coaxial cable. The extent of this construction, where and when it will be undertaken, will depend upon the requirements of our armed forces, general business conditions, the volume and distribution of long

distance messages, the availability of necessary manufactured cable and equipment, and other factors. Tentatively, however, Bell System plans call for between six and seven thousand route miles of coaxial cable in the next five or six years, representing an investment of something in the neighborhood of $100,000,000.

The adjoining column and the map on page 6 show the routes over which coaxial or equivalent facilities are being planned in the present program. The routes indicated are those where the need for additional telephone channels in substantial quantity is expected to be the most urgent and where the provision of coaxial cable appears to be the most desirable method of meeting this need. When coaxial facilities are being constructed for telephone purposes, it would be possible to provide additional conductors for television, and it is planned to do so if then it appears likely that there will be a demand for such facilities sufficient to justify the large additional investment.

REQUESTS for television facilities over routes where coaxial cable is not being planned during this period for telephone purposes would be considered on their merits. The question of when such facilities could be provided would depend upon conditions in the individual case and its relation to the total program. It is, of course, in the interest of economy to provide for television requirements in connection with providing cable for telephone purposes to the extent possible.

The equipment now developed for use with coaxial cable will give a one-

Tentative Program of Coaxial Cable Routes

Bell System

APPROXIMATE DATES at which television transmission facilities might be made available, if demand justifies their provision and manufactured cable and equipment can be secured, in accordance with present tentative program for extension of principal coaxial cable or equivalent routes for telephone purposes:

1945

New York-Washington.

1946

New York-Boston.
Washington-Charlotte.
Chicago-Terre Haute-St. Louis.
Los Angeles-Phoenix.

1947

Chicago-Toledo-Cleveland-Buffalo.
Southern Transcontinental Route (a large part) will include Charlotte-Columbia - Atlanta - Birmingham - Jackson - Dallas - El Paso - Tucson-Phoenix.

1948–1950

Southern Transcontinental (complete).
Washington-Pittsburgh-Cleveland.
St. Louis-Memphis-New Orleans.
Kansas City-Omaha.
Des Moines-Minneapolis.
Atlanta-Jacksonville-Miami.
Los Angeles-San Francisco.

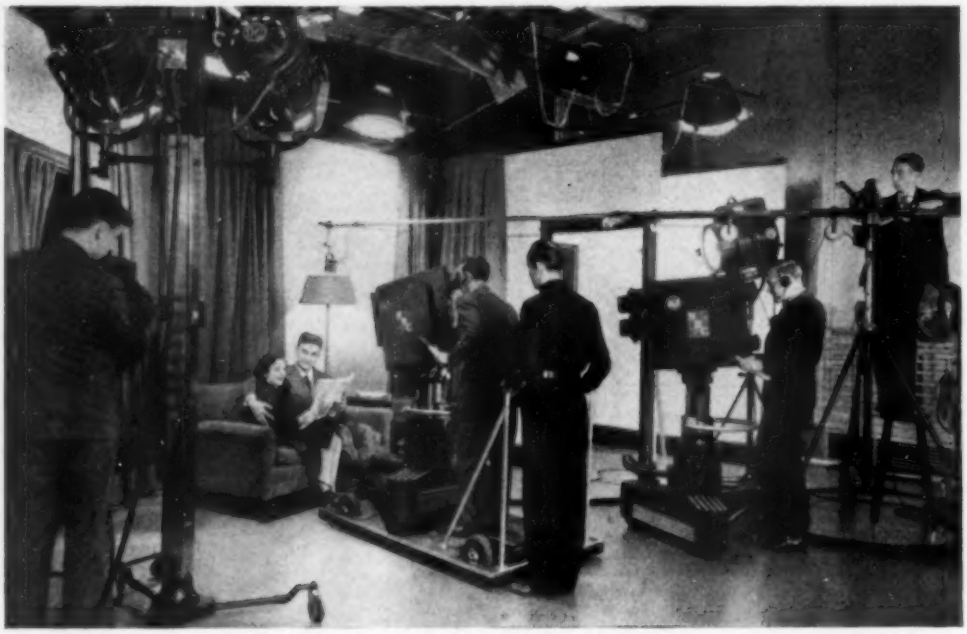
THE ROUTES INDICATED are subject to review prior to the time construction would be started.

THE LIST does not include additional sections which might be advanced into this period should important television requirements arise which would warrant routes or sections being installed well ahead of telephone requirements.

way television channel transmitting an effective band 2.7 megacycles (2,700,000 cycles) in width by the exclusive use of a single coaxial unit or pipe. A rough idea of the capacity of such a frequency band width to carry television signals can be had from the fact that 480 telephone circuits can be provided over a single pair of coaxials with present amplifying equipment. The trials which have been made over existing coaxial cable routes have indicated that such a channel will permit the transmission of very satisfactory television pictures.

Future technical developments will increase the band width to 4.0 megacycles, which will, of course, permit a still better picture. Facilities for still wider band widths, should they be required by the industry, would require further development work.

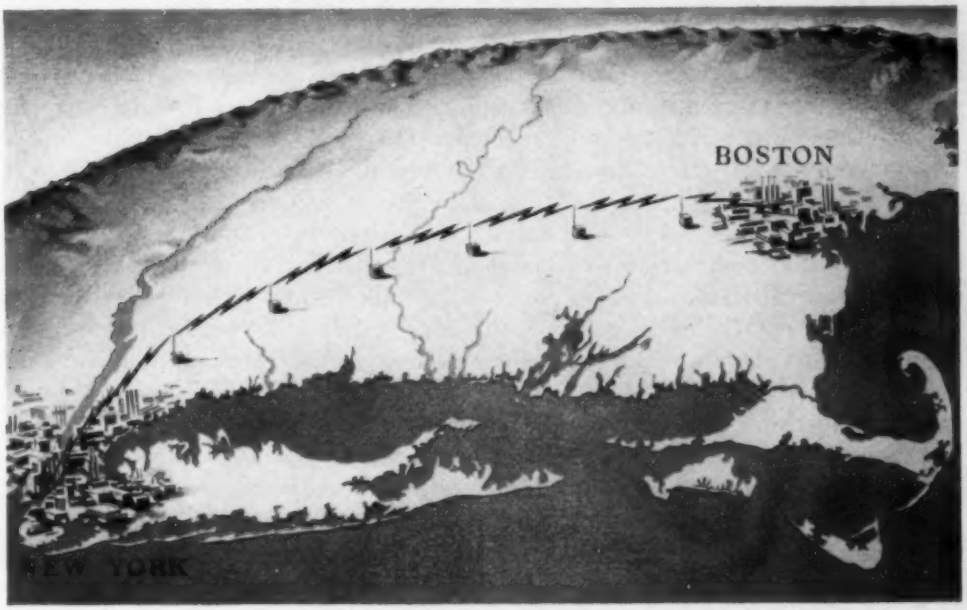
Future developments are also expected to provide for simultaneous use of a single coaxial unit to transmit a television channel and a large number of telephone channels. Consequently, the ultimate number of television facilities which could be provided over these cables will be considerably greater than the initial number. These ultimate possibilities must, of course, be taken into account in determining the number of coaxial units to be installed in the cables.



So SIMPLE an indoor set and action as that shown here requires a good deal of equipment for "telecasting"

In addition to its program for the

construction of coaxial cable, the Bell System is planning a trial between New York and Boston of a radio relay system which will be suitable for the transmission of television as well as telephone messages. This new system is of a type which was under development by the Bell Laboratories prior to the war, and applies to communication by radio many of the techniques which have played an important part in the development of long distance telephone circuits. Directed radio beams at ultra high frequencies will operate simultaneously in both directions and these will be relayed at stations spaced at an average of about thirty miles throughout the route.



AN EXPERIMENTAL radio relay system. This sketch shows how New York and Boston may be linked by telephone facilities which supplement long distance wire lines and also provide for television transmission

This project represents another step in the march of radio telephony to utilize shorter and shorter wave lengths. Overseas commercial radio telephony to England was initiated by the Bell System in 1927 using very long waves. Soon afterward short waves were developed for trans-oceanic telephony. Using still shorter waves, only two or three meters long, which do not travel much beyond the horizon, radio telephone service was established just before the war across Chesapeake and Massachusetts Bays. The new project proposes to use micro-waves which are shorter than have heretofore been used for commercial telephony.

The principal purpose of the trial

is to determine, first by experiment and then by practical operation in commercial service, the relative advantages and disadvantages of radio relay in transmission of long distance messages and television programs compared with transmission by other means. Relative costs represent only one of the factors to be determined; others include the relative quality of transmission, flexibility under actual operating conditions, and dependability. It is hoped that the new radio system will prove to be valuable as an additional means of meeting both telephone and television communications requirements.

THE PLANS which have been discussed for the construction of coaxial cable or equivalent facilities are necessarily very tentative. A great deal of work is, of course, required on the part of the television industry before we can know and plan accurately for its future needs for network facilities. Depending upon the speed of growth of the industry, therefore, it may be necessary for broadcasters and other users to do some sharing of television network facilities for a few years. This is one of the many problems which must be worked out during the early stages of development of the new television industry.

Where television facilities are required within a single exchange or between near-by exchanges, it is feasible to provide them within reasonable limits by means of ordinary telephone circuits with suitable equipment, or to provide them by circuits especially designed for the purpose.

The Bell System is doing everything it can practically to coöperate in the development and extension of television, just as it has coöperated in the distribution of sound programs. To that end, it is keeping closely in touch with the plans and requirements of the television industry, as they develop, and arranging its plans accordingly. By doing so, it hopes not only to make its own plans wisely but to be of maximum service to the television industry.

NEITHER BOARDS OF DIRECTORS nor the conduct of business has been perfect in the past, nor are they likely to be in the future. But the large publicly owned enterprises, controlled by boards of directors and managed largely by men who came up in the business they managed, performed rather better than most business during the depression. Financially, they survived better than small business or farmers or most other activities. They did as well or better than any other group in providing jobs, raising money and paying taxes. They maintained wages better than other groups. The breakdowns in character in big business from the nature of the case are more spectacular than those in little business, but the actual proportion is probably smaller. And it ought to be, for the public has a right to expect greater responsibility, and greater wisdom in the moralities in big enterprise than in small ones.

From "The Bell Telephone System," by Arthur W. Page, Vice President, A. T. & T. Co. Harper & Brothers, publishers, 1941.

A Bell System Committee Has Been Working with the Armed Forces to Bring About Greater Efficiencies in Their Telephone and Teletypwriter Communications

A Review of Army and Navy Communication Facilities

Myron F. Dull

FOR YEARS the Bell System's customers, large and small, industrial, mercantile, and governmental, have been accustomed to look to their telephone companies for assistance with their communication problems. All of the System operating companies have servicing organizations for this purpose, and never before has this work been so important as now, in the midst of war.*

The Associated Companies and the Long Lines Department have been giving day-to-day counsel to the Army and Navy at their individual establishments right along. More recently, both Services have also turned to the System for assistance on a nation-wide basis in coöperation with their own communication specialists.

The Army provides a good illustration of the communication problems with which both Services have been faced. Its normal peace-time military personnel numbered about 200,000 men. True, administering the activities of so many people, especially when they comprise many small units scattered from coast to coast, requires a good deal of communication. Nevertheless, the Army found that, with private branch exchange switchboards (PBX's) in its military establishments, with the use of long distance telephone service, the mails, and commercial telegrams, and with the operation of its own radiotelegraph channels between Washington and the nine Service Commands (or Corps Areas, as they were formerly called) into which the continental United States is divided, its communication needs could be served very comfortably.

Then came the outbreak of war in Europe. Germany invaded Belgium and the Netherlands, sweeping all opposition before it. Dunkirk followed. France fell. Britain was besieged

* See "Telephone Service for War Industries," MAGAZINE, June, 1943.

from the air and its invasion seemed imminent. For us in the United States it was a time of deep apprehension. And so, we looked to our defenses. The Neutrality Law was rescinded. The 50 destroyers were exchanged for bases. We adopted Lend Lease, became the Arsenal of Democracy. Congress passed Selective Service.

Communications Also Grew

ALL THE WHILE, of course, the Army's and Navy's communications were feeling the impact of these historic developments. With the coming of the draft, the building of camps and cantonments, the construction of powder plants and arsenals, and the expansion of war industries, communications leaped skyward.

Then came Pearl Harbor. Soon the Army numbered millions. Soon there were hundreds of military establishments. Soon there were thousands of industries making war materials, shipyards building cargo and war vessels. Soon also there was the submarine menace and the threat of air attack. All these matters had to be planned for and administered and coördinated to a central purpose, with haste, through communications.

Obviously, the radio channels between the Service Commands were insufficient to meet these stupendous and ever-mounting needs. The use of long distance telephone service by the Armed Forces grew apace. Even greater, relatively, was the growth in teletypewriter service. Use of the teletypewriter was quite natural, because it provides such an efficient means for handling swiftly the written communication which is vital in so much of military administration.

For purposes of illustration, let us narrow the focus, so to speak, and single out just one military establishment—almost any one would do. It has been decided, let us say, to build an Army camp. First come the Engineers, to survey and supervise construction; they need communication with Washington and also with their Service Command headquarters. Telephones and teletypewriters are installed for them. As construction proceeds, soldiers move in, and the Quartermaster Corps, the Ordnance units, Medical Corps, and other branches now have communication needs—with Washington and other places. They too have teletypewriter service. All this, it should be pointed out, is in addition to the PBX service which has by this time been installed to serve the entire establishment's telephone needs.

IT WAS through a process such as this, in sum, with so many divisions or branches adding facilities to meet their own immediate and individual requirements, that hundreds—even thousands—of separate communication services were established all over the country. It could hardly have been otherwise. Speed, it must be emphasized, was of the essence. There was no time in those early, urgent days of the war for full consideration of how to secure maximum communications efficiency for the Army as a whole. There was no time for lengthy consideration of whether some integration or coördination of wire facilities would be more efficient, or whether one type of grouping would be more efficient than some other. Central control, supervision of these thousands of

widely scattered installations, in those critical days was next to impossible.

Meanwhile, shortages began to develop in the very materials which are most essential in communication equipment: copper, rubber, aluminum, steel, etc. Demands for communication equipment from the Army contingents already overseas were beginning to make themselves felt. Its conservation became more than merely desirable; it became vital to the success of the war effort itself.

Recognizing this, as well as the duplications and potential inefficiencies in the kind of expansion which had taken place, the Signal Corps early took action. To understand its scope, it must be realized that not all military communications fall into the same category. While all are important, there are varying degrees of speed and security and other requirements which materially affect the type of service to be used. Generally speaking, fast written military communications fall into one of the following classifications:

Tactical operations, requiring practically instantaneous contact

U. S. ARMY SIGNAL CORPS PHOTO

WACs receiving Army messages on page-type teletypewriters in a War Department Signal Center. Thousands of messages are sent and received daily in these Centers over teletypewriter facilities

and usually calling for immediate acknowledgment or back-and-forth "conversation."

Other operations, where somewhat slower speeds are satisfactory but which may call for back-and-forth "conversation" in some cases.

General administrative and other functions with varying speed requirements and little need for immediate back-and-forth "conversation."

Teletypewriter Network

THE SIGNAL CORPS believed that if, for example, the many individual teletypewriter services devoted largely to the administrative type of message could be welded into an over-all and coherent system, greater efficiencies and economies, better service, and savings in critical materials would accrue. The Signal Corps thereupon evolved a plan for coördinating these communications, called the Army Command and Administrative Network. (There are also in existence several large Army communications networks serving special requirements, especially in the Air Force.)

In order to visualize the Administrative Network, a few basic facts about teletypewriter service must be understood. Bell System people are, of course, familiar with the teletypewriter itself: that amazing machine which, by transmitting certain combinations of electrical impulses, reproduces typewriting instantaneously on a similar machine at a distance. What may not be known to everybody, however, is that there are two forms of this service. In one, called private-line or leased-line service, teletypewriter machines are connected with each other by direct circuits reserved exclusively for their own use. In the other, called teletypewriter exchange service (commonly abbreviated to TWX), each machine is connected with a teletypewriter central office, which can connect one machine with another in much the same way that a local manual central office or toll office switches telephone calls. Indeed, a TWX subscriber has a teletypewriter number, just as a telephone subscriber has a telephone number.

The typed message may appear either on paper tape, which is about a half-inch wide, or on a full-width page, depending on the type of machines used. Moreover, there is apparatus which can cause the teletypewriter message to come out in the form of perforations in the tape; and it is possible also to have the typing itself superposed upon the perforations so that the message may easily be read. This perforated tape can then be fed into an automatic transmitter, whereupon the perforations produce electrical impulses which transmit the original message to still another machine, either in tape or page form or again on perforated tape, thus enabling this process to be repeated. The Signal Corps plan for an Army Command and Administrative Network takes advantage of this latter facility.

IN BRIEF, this plan provides that so-called Signal Centers be set up in various cities throughout the United States, connected with each other by a network of private line teletypewriter circuits. Military establishments or units within the area covered by each Center would have

access to it by private line teletypewriter, TWX, or commercial telegraph —depending on the character and volume of the traffic.

To visualize the process, assume for a moment that one Army unit wants to get a message to another that its destination is reached via another Signal Center in a distant city. This tape is simply inserted into the automatic transmitter connected by a private-line circuit with that Center, and in a few moments the message appears at the latter point, again on

U. S. ARMY SIGNAL CORPS PHOTO

WACs receiving and sending Army messages with automatic equipment in a War Department Signal Center. This photograph illustrates the relay method of handling teletypewriter messages by means of perforated tape

and that both are equipped with teletypewriters. The sending point teletypes the message to its Signal Center. There the message comes off the receiving machine in the form of perforated tape plus the typing itself. An attendant examines the tape, noting from the address on the message perforated tape. The attendant at that point, noting its destination, inserts it in a transmitter connected, either by direct circuit or TWX, with the teletypewriter machine at the terminating point.

Those familiar with teletypewriter operation will quickly recognize that

this service is not as fast as either private line teletypewriter service or TWX. The point is that, to care for administrative communications of the type being considered, it does not have to be. Because of the nature of these communications, a few minutes more or less between sending and receiving points do not matter. Back-and-forth "conversation," to which TWX or private line teletypewriter service lends itself, is not required. Why use a superior facility when a slightly slower and more economical method will fully suffice? Moreover, the concentration of communications at the Signal Centers would permit a fuller and more efficient use of the intercity teletypewriter circuits. That is, transmitting the messages of many units over a unified network would spread the load and produce a more even flow of traffic, compared with the then existing situation of sporadic communications by individual users without regard to the usage of others. This was how the Signal Corps reasoned.

The Bell System Committee

IN NOVEMBER, 1942, the Bell System was asked by Brigadier General Frank E. Stoner, Chief of the Army Communications Service of the Signal Corps, and Rear Admiral Joseph R. Redman, Director of Naval Communications, for advisory assistance in connection with their respective leased-line telephone and teletypewriter services. This obviously involved a nation-wide review which was in some respects beyond the scope of any one Associated Company or Long Lines individually, and necessitated formation of a group representing the Bell System as a whole. Such a committee was formed, consisting of Myron F. Dull of the A. T. & T. Company's Department of Operation and Engineering, Richard W. Miller, Russell J. Anspach, and Roy S. Breese of the Long Lines Department, and Bruce E. Osgood of the Michigan Bell Telephone Company. Offices are maintained in the Pentagon, at Washington, permitting close daily contact with Signal Corps and Navy communications people.

One of the more specific requests made by General Stoner had to do with the Army Command and Administrative Network. Reduced to simple terms, he wanted to know whether this plan was likely to be the most effective among several which might be employed; if so, how many Signal Centers there should be and where they should be located; what the traffic volumes were likely to be between the Centers and how many teletypewriter circuits would be required to handle this volume; and what private-line service then being subscribed for by the Army might be integrated into this network.

When this committee first convened, with all of the potential communication problems of the Armed Services buzzing in its ears, so to speak, it faced a situation of tremendous size and complexity. Here was a mass of communication facilities to be surveyed, consisting of 400,000 miles of telephone and teletypewriter private lines, 2,600 TWX stations having a usage totaling roughly half that in the Bell System as a whole, scores of radio channels, and millions of message toll calls. Where to start? First things first, of course—but what should come first?

The First Question

THE initial problem in this regard was to decide as between the telephone and teletypewriter services. It was soon evident that the teletypewriter problems were the more pressing at that particular time. First of all, there was the importance of the written word in Army administration. Selecting teletypewriter service for first attention would, moreover, most quickly permit determining the relative effectiveness of the Signal Corps Network plan. Since this plan was actually in process of being placed in effect, a recommendation in this matter was indeed a first order of business.

This recommendation was soon forthcoming. A preliminary investigation made it apparent that the Signal Corps was proceeding along sound lines. The main problem was to expedite the conversion of many of the individual teletypewriter services and TWX usages into such a Network as quickly as possible. Speed in lightening the load on the general TWX facilities was indicated by a twofold urgency: that of service to the Army itself, which was encountering TWX bottlenecks caused by its own traffic volume; and service to the war industries and other government agencies which made up a large part of the remaining TWX traffic volume.

Compared with what had to follow, this was simple. The next problem—that of assisting the Signal Corps to engineer the Network—was staggering. Engineering requires facts: in this case, a great mass of detail. An outline of some of it—remembering that there were thousands of teletypewriter stations scattered throughout the country—will give some idea of the magnitude of the fact-gathering task:

For each private line teletypewriter service:

—the terminal points and the name and location of the Army unit subscribing for it.

For each TWX service:

—the name and location of the Army unit;
—the number and type of the teletypewriter machines;
—their recent usage; and
—the geographical concentrations, if any, in this usage.

IN ADDITION to the Army's coöperation the committee had, of course, the assistance of the Associated Company and Long Lines servicing forces. Regional meetings with representatives of these forces were held in Philadelphia, Washington, and Chicago, to discuss the problem and to seek their advice.

The servicing people of the Associated Companies and Long Lines, working with the Service Commands, promptly undertook the huge task of gathering and analyzing this information. These data were then reviewed by the committee, plotted on maps, and thus dovetailed to see if this enormous amount of communication facilities conformed to any nation-wide pattern, and, if so, what this pattern was.

Obviously, such a pattern had to be crystallized with a considerable degree of accuracy, since otherwise it would be impossible to recommend where the Signal Centers should be located and the number of circuits required. This analysis indicated that the Network might well be ex-

panded to include some 30 Signal Centers.

Parenthetically, this recommendation was complicated by the necessity for taking into account not only the Army's traffic but also the availability of telephone company facilities from which the needed circuits could be drawn.

Covering Ground

DESPITE the tremendous help given by the operating people in the field, the committee often found it necessary to familiarize itself with conditions at first hand. It is no exaggeration to say that one or another of the committee members has visited every important military establishment in the country at some time in its fact-finding activities. Transportation has varied from milk train to airplane. In one case, for example, in order to review the requirements of one large Air Force network it was necessary to visit establishments in Alabama, Florida, Georgia, Louisiana, Michigan, Mississippi, Ohio, Oklahoma, Pennsylvania, and Texas.

In addition to engineering the Signal Center locations and their interconnecting circuits, it was necessary to consider, jointly with the Signal Corps, which of the many Army units throughout the country could profit by access to the Network, and whether this tie-in should be by private line teletypewriter or other means. It was found that some 400 of them could advantageously route all or part of their traffic over the Network in addition to those which were already doing so. All told, about 20,000 minutes of TWX usage daily, mostly long haul, may ultimately be converted to the new Network—to the considerable relief of the general TWX facilities.

Among the committee's recommendations was the recognition that this Network should not be regarded as a rigid blueprint—in other words, that there might still be a number of situations in which the nature and volume of the teletypewriter traffic between specific points would justify separate private line service. Actually, the TWX usage data accumulated by the Associated Companies was combed with this in mind. It is perhaps a tribute to the alertness of both the military users and the Associated Companies that only three instances have been found in which it appeared more efficient to establish private line service.

Of this Administrative Network, it seems fair to say, in conclusion, that its existence will not only result in more efficient over-all communication; at the same time it may enable the Army to curtail increases in other private-line networks and forestall installation of new ones for the individual use of various Army branches.

Other Undertakings

THE FOREGOING presents a broad outline of only one channel of the committee's work thus far. Coincident with the reviews of teletypewriter services, analyses of long distance usage have been under way, and many recommendations have been made, looking toward economies in the use of critical materials and greater efficiencies in handling the intercity telephone communications of the Armed Forces. For example, consideration has been given to the extent to which private-line telephone service can be utilized effectively. An

experimental installation of private-line service between New York and Washington has been made and is now being analyzed. These studies should prove useful in considering the possibilities of similar installations in other parts of the country, with important effects on the efficiency and economy of Army long distance service in general.

As regards the results of this activity as a whole—in terms of both equipment conservation and improved communications efficiency—perhaps an example or two would be helpful at this point.

In the Pentagon, which houses the War Department in Washington, there were 67 teletypewriter stations, distributed among 26 different locations throughout the building. A study indicated that these locations could be better served by 31 machines if all were placed in the Pentagon Signal Center. There would be a saving of 36 teletypewriters, and an equal number of cable pairs and TWX switchboard appearances, although some allowance might have to be made for certain machines equipped with special apparatus. Completion of inward calls would also be vastly improved, with corresponding improvement in the speed of Washington TWX service generally—as well as specifically on calls completed to the Pentagon. There are numerous other advantages from an Army standpoint, including improved supervision of message handling and efficiency of attendants. This recommendation has already been acted upon in part, and will be carried further as conditions permit.

CROSS COUNTRY flight communications are vital. Air Force, Signal Corps, and C. A. A. representatives completed a review of these communications on April 1, 1944. The author (left) participated, covering 10,500 miles by Army plane, visiting important installations throughout the country

In a case involving the Navy, TWX communications between a certain East Coast establishment and points on the West Coast were extremely heavy—so much so that serious overloads, with resulting service delays, were being encountered on the transcontinental TWX circuits. It was found here that the substitution of private-line teletypewriter service would have multiple advantages: speed the handling of important Navy Department messages, help to relieve the general TWX traffic situation in the East Coast city—and, withal, save the Navy Department money.

A review of the Navy's telephone communications between important centers on the East Coast was also made. It resulted in recommendations, now being carried out, which will make material improvements in the efficiency of Naval communications.

Results

THERE IS, of course, no yardstick by which to measure an activity such as that which has been described. It is impossible, for example, to state in figures the results of the most important objective of this work—which is to assure that, in so far as practicable, facilities involving critical materials are being used to their maximum efficiency and that the users have the lowest possible costs consistent with adequate and dependable service. There are intangibles even in the matter of equipment conservation, although where it was feasible to accumulate such information, records have been made of the following savings:

26,000 air line miles of telephone circuits and 13,000 air line miles of teletypewriter circuits have been released for service in the general telephone plant;

900 units of teletypewriter apparatus, mostly teletypewriter machines, have been disconnected and made available for other uses;

$1,900,000 worth of communications equipment, either already in service or actually ordered for installation, composed largely of critical materials, has been saved.

Recommendations which result in such savings as these are, of course, made only where they will at the same time produce a satisfactory service. Incidentally, these conservation achievements will be accompanied by savings in the Armed Forces' communications expenses of approximately $3,500,000 annually, counting the recommendations for changes which are now in process of being effected.

But the foregoing are only what might be termed the "positive" savings: those which pertain to facilities actually discontinued or those on order which were canceled. There have also been uncounted savings, attributable at least indirectly to some of this work, in equipment which doubtless would otherwise have been ordered but was not. Joint efforts of the communications branches of the Armed Forces and the committee, through meetings, letters, and bulletins, have fostered a "conservation consciousness" in the far-flung Army and Naval organizations. In June, 1943, for example, all Service Commands were called upon to release telephone instruments and TWX stations considered not absolutely essen-

tial; similar action was taken by the Navy. Whereas prior to June there had consistently been an increase in TWX stations subscribed for by the Armed Forces, there has since been a continuing decrease. Some 14,000 telephones have also been released.

Wherever expansion of the Army's Administrative Network has been recommended, the necessity for action to insure continuity of experienced people has been emphasized. The very first report to General Stoner recommended the use of WACs, and these young women are now being assigned for the all-important Signal Center operation. Practically all of the training of teletypewriter operators used on the large Army networks had, initially at least, been given by Bell System instructors. Now, however, because of the vast increase in its requirements, the Army plans to train some of its own people as instructors. It was recognized that, to facilitate this, some of the A. T. & T. Long Lines Department's training material would prove useful, and this material was revised and made available to the Army.

Furthermore, the information gathered for the analyses has provided the Army with basic data to assist in establishing its own system of record keeping. These records have better enabled the Army to visualize its communication problems and formulate judgment with respect to desirable equipment rearrangements, additions, and deletions.

THIS STORY could not properly conclude without a word of personal comment, on behalf of the entire committee, regarding the wholehearted and friendly coöperation which has been received throughout from the members of the Armed Forces and from Bell System people with whom the committee has dealt. Such contributions as the committee has been successful in making to the work of the Army and Navy, and thus to victory, have been due in large measure to this very willing and indispensable assistance.

THE NATIONAL SECURITY AWARD, established to "recognize superior organization for plant protection and security," has been granted simultaneously to the Associated Companies and the Long Lines Department of the Bell System by the U. S. Office of Civilian Defense.

"The coöperation of the telephone industry in civilian defense and war programs has been so complete and so thorough that it is an outstanding example of the patriotic conversion of an entire industry to wartime needs," said Lt. Gen. William N. Haskell, Director of Civilian Defense. "For security reasons, we cannot yet tell the whole story of the many measures which the telephone companies have taken to safeguard our vital lines of communications during these war years. However, we can say that in setting up complicated warning systems and in other ways the telephone companies have extended to Civilian Defense a high order of coöperation."

In This Conflict, for the First Time in History, Radio Telephony Permits a Sea Commander to Dispose His Ships Wherever He Chooses over the Broad Area of Battle

The Telephone Remakes Naval Warfare

Fletcher Pratt

The phrase "The telephone has gone to war" means, among other things, that the telephone industry's manufacturing capacity is now devoted almost wholly to producing electronic and communication equipment for the nation's armed forces. That explains in part why there are not enough telephones to "go around" among civilians. In the following article Mr. Pratt gives an authoritative picture of the telephone's part in several crucial naval actions of the present war; and from it the reader may infer the urgency of concentrating the production of communication equipment on combat items.

THE NAVAL WAR of today differs more from that of World War I than the latter did from the Civil War of 50 years before. This is obvious when we compare the swift whirlwind action of ships all over the ocean that Guadalcanal and Midway saw with the long lines of battleships at Jutland twisting and weaving through an afternoon—just as they did in the days when Lord Nelson expected every man to do his duty under tall pillars of sail.

The airplane has something to do with the change: at Midway one of the most desperate battles of modern times was fought out without the ships coming in sight of each other. But this and other differences are of weapons merely; they time the naval battle for midnight or move the opposing fleets apart as they had already been moved apart by the range and power of modern artillery. The essential structure of the naval battle would have remained unchanged but for the appearance of another new weapon.

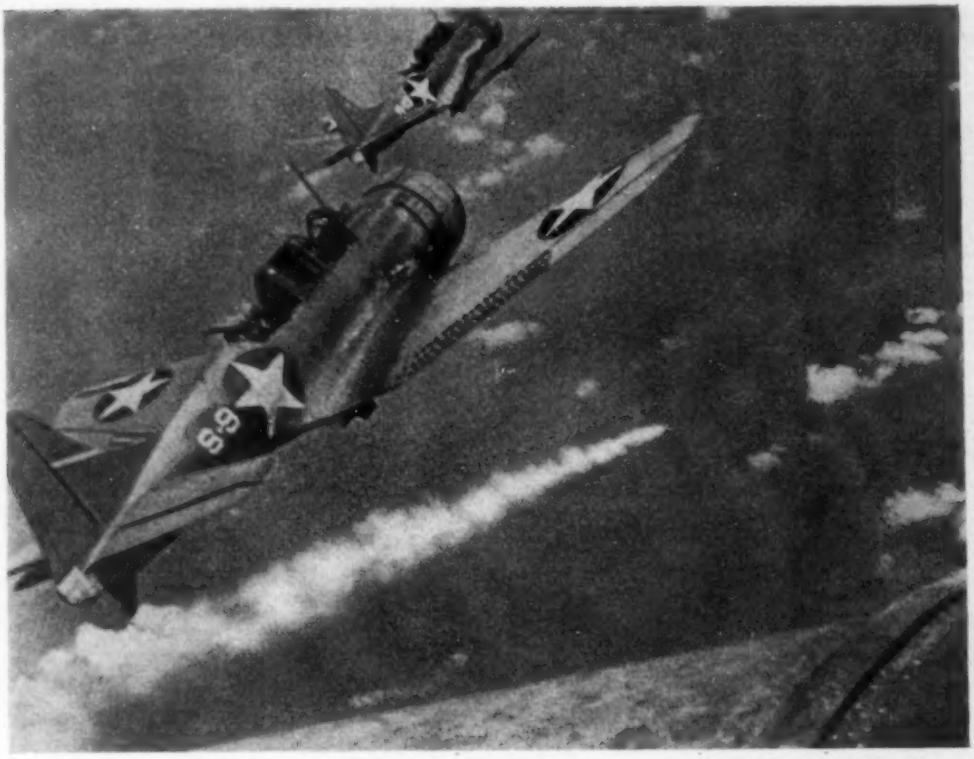
That new weapon is the telephone.

Specifically, the radio telephone, both in its long-range form and in the more limited variety known in

the navy as the TBS ("talk between ships").

Its beginnings were toward the close of the last war, among the tiny motor sub-chasers working to keep the English Channel free of U-boats. In addition to the earliest radio telephones, they carried the first crude sound gear for locating submarines, which would give them the direction but not the distance of the enemy's motors, heard under water. Accordingly, they worked in groups of three. When sub-chaser 316 (for instance) heard the exciting noise, it would open up its TBS to tell the other two working with it "I have a submarine on bearing 345." Sub-chaser 317 would listen and reply, "He bears 194 from me"; and sub-chaser 318, "He bears 092 from where I am." On all three sub-chasers, officers would draw lines on charts in the directions given; where the three lines intersected, the U-boat would infallibly be; and they could trot over and drop depth charges.

The TBS of those days was a pretty



OFFICIAL U. S. NAVY PHOTOGRAPHS

DEATH OFF MIDWAY. In an enlargement from an original 16 mm. film, this photograph shows Douglas Dauntless dive-bombers making their run before dipping down to smash at Japanese warships during the titanic battle of Midway in June, 1942. This picture, made on June 5, 1942, shows one Jap warship burning fiercely far below.

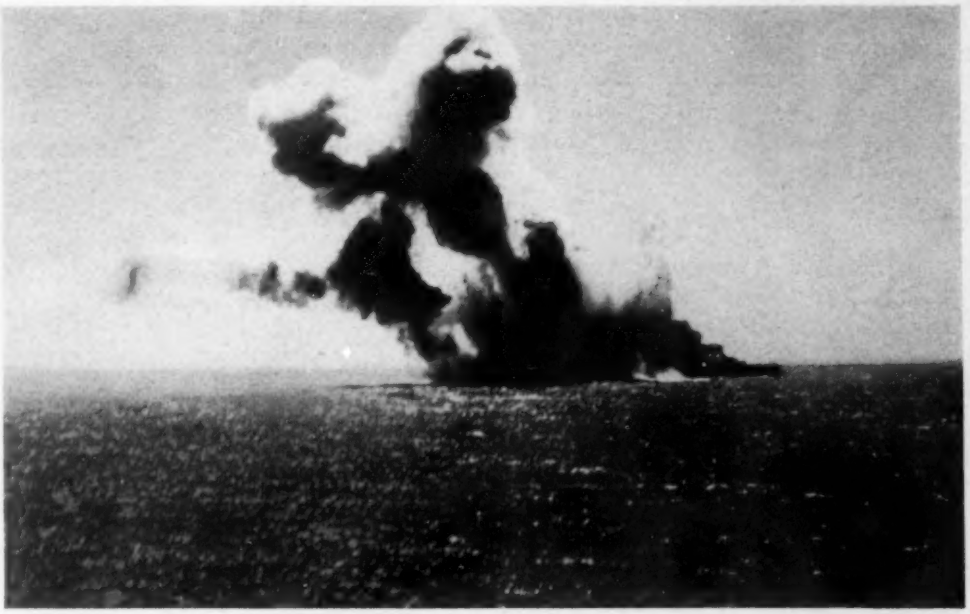
ineffective instrument, no use unless the ships carrying it were but a few hundred yards from each other—and not much use even then. But if the British had had even so imperfect an instrument at Jutland, they could probably have wiped out the German fleet and shortened the war. Communications in that battle were mainly by searchlight and signal flag, because the coded radio was too slow. Admiral Jellicoe had to keep all his ships in close visual touch with each other. As a result, the well-beaten Germans slipped round his massed ships during the night and got away to harbor. During a great deal of the battle, in fact, the British admiral did not know where all his own ships were. With TBS, he could have used his battleships in long open formations, concentrating against the enemy the moment any of them made contact.

That is, the telephone, so much faster and more accurate than written radio telegraph dispatches, permits a sea commander to dispose his ships wherever he chooses across the broad area of battle, summoning them together for sudden attacks on a wing of the enemy's fleet. It is no longer necessary, as in all the past history of naval war, for the admiral to be in the leading ship, with the others strung out in a long, rigid line behind him, conforming to the movements of the flagship because there is no sure way of telling other ships what he wishes them to do. In fact, the

NIGHT ACTION. In battles like this, fought at hot speed with ships close to each other, communication would be impossible without the use of such devices as the radio telephone

admiral does not have to be on a ship at all.

This is illustrated in a minor sense by one of the most difficult of naval operations: the making up of a convoy. It involves bringing out of port and into formation at sea many ships, of varying speeds, whose captains do not have the training of naval officers in precision maneuvers and split-second timing. Directions to the ships from the convoy commodore by flag signal were often misunderstood; using radio telegraph is an invitation to every submarine within hundreds of miles to come jump on the convoy while it is least able to take care of itself. But these days the convoy commodore can go aloft in a blimp or plane and, opening up his short-range radio telephone, talk to each ship in turn or all together, telling exactly where he wants them to go and at what speed.



"SCRATCH ONE FLAT TOP!" The Japanese carrier *Ryukaku*, hit and exploding in the Battle of Coral Sea

The Battle of Midway

OUR NAVY has used the radio telephone in the tactical field also, with outstanding results. Midway would have gone into the books as a drawn battle or even an American defeat but for this.

Consider the situation on that morning of June 4, 1942. The Japs had violently attacked the island, and planes from Midway had counter-attacked the Jap fleet, damaging some of its vessels. Their carriers had turned away under cover of an overcast to refuel planes. Our own car-

riers had flown-off their attack groups of torpedo- and dive-bombers but, thanks to the Jap movement and the clouds, these were hunting for the enemy in vain, all but one group—the famous Torpedo Squadron 8. They found the Japs, but their fuel was running low. Squadron Leader Waldron opened up his voice radio and gave the position. "Request permission to return to carrier for fuel," he added.

Now, he was the man on the spot, an able leader and a first-class fighter. Without the voice radio, his judgment would have been the ruling one on what to do, and his judgment was to break away. But Admiral Spruance, to whom he had spoken, knew better; knew that the dive-bombing groups and the rest of the torpedo planes were only a few minutes' flying time distant; that if he recalled Torpedo 8 now, the Japs would almost inevitably find his carriers and hit him before he could hit them. "Attack at once," he telephoned back, and at the same time notified the rest of the planes where the enemy was. All our groups poured in on the Japs in one of the greatest airplane attacks ever delivered, sank four enemy carriers, saved Midway, saved Hawaii, and saved the war for us right there!

In the Coral Sea

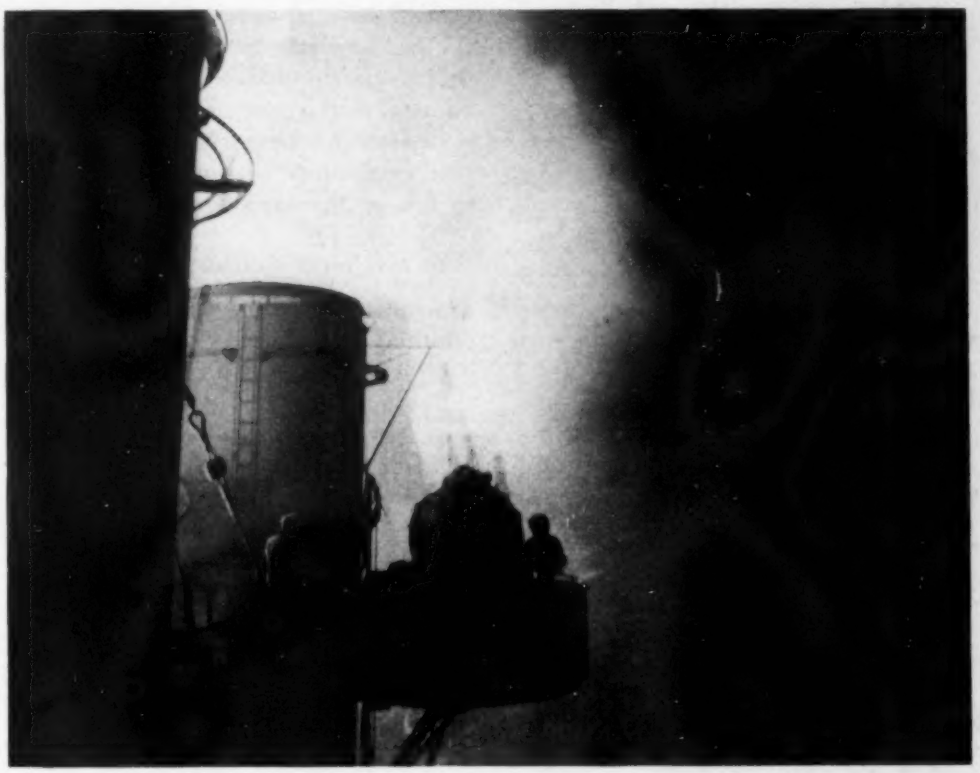
THE NEW dispositions made possible by telephone were perhaps even more decisive in the strategic range during that earlier confused, desperate four-day series of sea-air fights which are called collectively the Battle of Coral Sea. The problem in that case was one of information, with neither side knowing the strength or intentions of the other. Actually the Japs had four complete fleets in the area: two of them invasion groups consisting of transports covered by such light craft as cruisers and destroyers; two of them powerful carrier striking groups including battleships. One of the battle fleets was covering one of the invasion groups as it swept down from the north to set up a new base on the islands at the eastern tip of New Guinea. The second invasion group was similarly occupying Tulagi Harbor and the island of Guadalcanal in the Solomons, while the other battle fleet was swinging wide to the east around the Solomons to trap in the Coral Sea any American forces that might try to interfere.

Admiral Frank Fletcher was in that sea with the carriers *Lexington* and *Yorktown*. On the afternoon of May 3 one of his scouts just lifted a wing over Guadalcanal and spied the Jap invasion fleet at anchor. "Joan to carrier," he said over the voice radio; "concentration enemy shipping Tulagi Harbor." At the same time Fletcher had word from Australian air scouts of the great double Jap fleet coming down toward the tip of New Guinea. He had located three-quarters of the enemy armada, so much larger than his own, and they did not know of his existence—at least not till the dawn of the morning of May 4, when the planes of the Yorktown's powerful striking force fell on Tulagi from the sky and wiped out the Jap invasion fleet there for our first victory of the war.

AS SOON as he had won it, Fletcher turned west and steamed at hot speed for the waters south of New Guinea. Once more the Japs did not know of his presence, for he had used only

short-range voice radio telephone—and so kept them from getting a fix on him with their radio direction finders. When, on the morning of May 6, the striking forces were flown from the *Lexington* and *Yorktown,* they found the Jap carrier *Ryukaku* just turning into the wind to launch planes, and slapped at least 10 torpedoes, at least 15 heavy bombs into her. Commander Dixon opened up his long-range radiophone to shout the jubilant message that has become a classic: "Scratch one flat-top."

Now the interesting thing about both the Coral Sea and Midway actions is that they were, in a sense, conventional naval battles. The use of airplane striking forces had moved the fleets out to 200 miles apart instead of the 200 yards of the days of sail, but the procedure was essentially what it had always been. The admiral's flag was on the leading and most powerful unit; the others followed her movements but used their offensive powers (in the two cases, airplanes) pretty much at their own



BATTLE BY NIGHT in Kula Gulf. Most naval actions in this war have been fought in the dark and have lasted only a few minutes. The TBS circuit enables captains to get in direct communication with and identify their neighbors

discretion against whatever ships of the enemy they chose. There was some tactical difference between Coral Sea-Midway and the old pattern of battle, to be sure; a difference brought about by the telephone in the form of TBS. But it seemed a minor matter at the time.

Signals vs. Speech

THIS DIFFERENCE lay in the exquisite control over his other vessels that an admiral aboard a carrier was able to exercise through the new instrument. When Jellicoe at Jutland wished his leading division of ships to alter course or speed, he had to tell his flag lieutenant, who wrote an order which the Admiral OK'd, reading something like "Flagship intends to turn five points to port and proceed at 18 knots."

This message was passed to the signal bridge, where the crew selected the proper flags, arranged them, and hoisted them to the yardarm. The ships to which the message was addressed read it, and ran up the same flags to show they had understood. When they had all done so, the Admiral would give the order *"Execute";* down came the flags, the Admiral's ship speeded up and made her turn. The whole process took as much as ten or fifteen minutes, and on several occasions during the smoke and confusion of the Jutland action some ships missed the signal so that the *Execute* was never given at all.

We can note that this process is altogether too slow for an action involving planes, whose attack is all over, success or failure, in the time necessary to give the signals. Without their TBS, Fletcher of Coral Sea and Spruance of Midway would really have had no communication at all during the hottest and most vital parts of the battles. But they did have TBS; they were able to pick up a phone and talk direct to the captains of the ships under their command, saying for instance, "I'm going to turn five points at twenty-eight knots." The process took no longer than it does to pronounce the words, the acknowledgment the same, and there was no chance of error. The admiral could even order the ships of his command to perform quite separate evolutions, or order all of them to fire on the same enemy.

The Battle of Guadalcanal

WHETHER anything like this was attempted at Coral Sea or Midway we do not know, and shall not till after the war, when the track charts that show the movements of the ships are published. But it is clear that the full possibilities of the telephone in naval war were realized and used at least by the night of November 15, 1942, in that tremendous and decisive action known as the Battle of Guadalcanal.

The Japs had come down from the upper Solomons with a squadron of battleships and cruisers to shell our positions on the island, and to bring reinforcements for their own positions aboard a fleet of transports. They had done it before, sometimes losing, sometimes winning, but never in such strength, and the battle for the island had reached its crucial stage.

That night Rear Admiral Willis Augustus Lee appeared off Guadalcanal with two American battleships. They steamed past the capes of the island, and picked up the approaching

Jap squadron. And it was with his TBS that Admiral Lee arranged a concentration on the leading Jap battleship. "Commence firing!" he said into the mouthpiece when he was sure both ships had the same target. They opened up together, hitting that Jap so quick and so hard that she never had a chance to reply, never fired a shot—and in five minutes 27,000 tons of battleship were on the bottom and the battle was won. The other Jap ships fought on, but the advantage gained by that first crashing concentration was such that the decision was taken and Guadalcanal was won.

More than that; for, as that action proved, the change in communication introduced by the radio telephone has brought about a complete change in the conduct of naval war. As soon as this was realized, and used to its fullest extent, we won a major campaign.

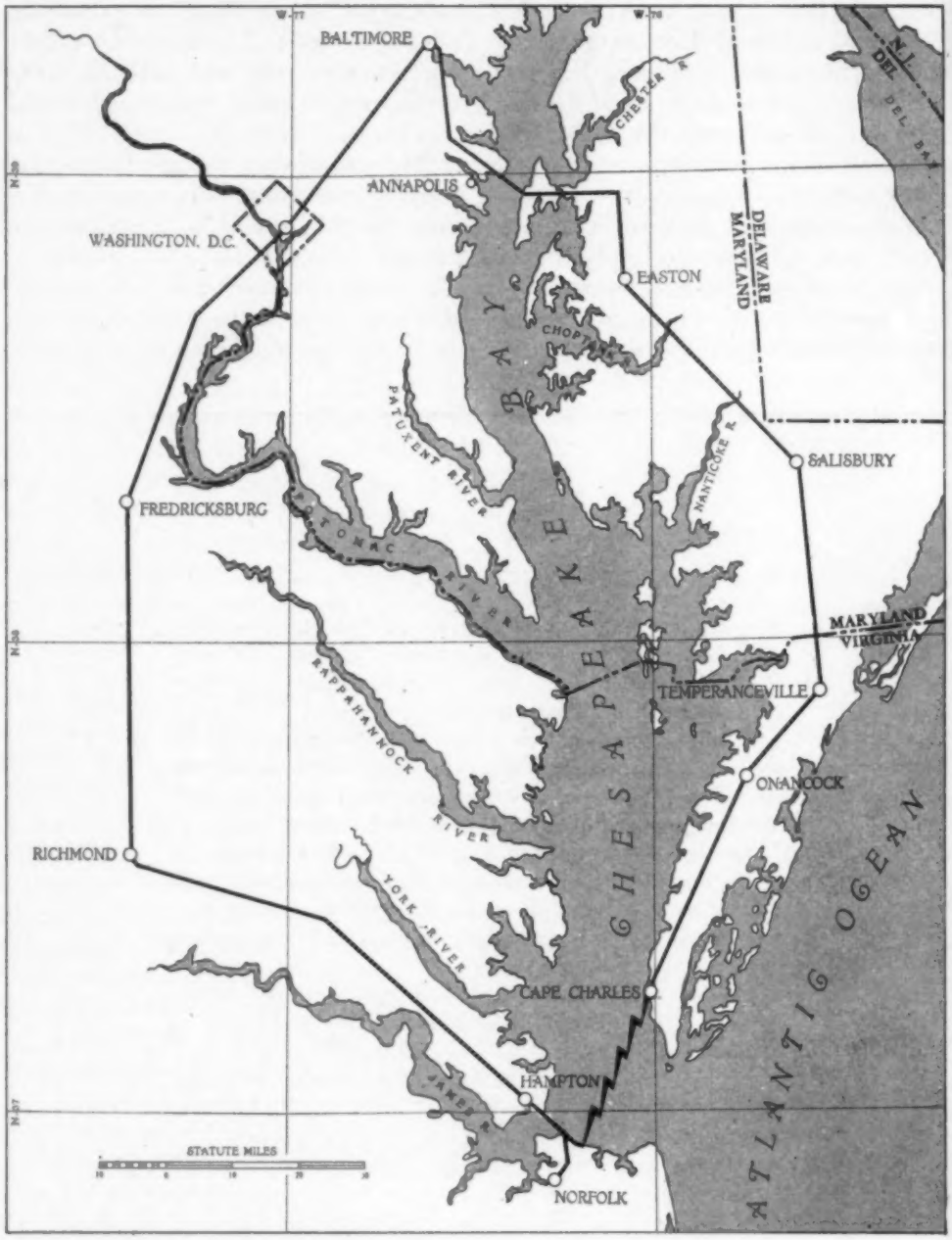
MY FINGERS build a bridge of words that spans the long miles between a lonely boy and home. Troops move and factories thunder into action obedient to the calls that speed through my switchboard.

A mother, a sweetheart, a wife wait by their telephones as I try to reach the soldier in camp or the sailor on shore leave. And usually I succeed, for I know the love and longing that lie behind those long distance calls.

The hopes, prayers, and fears of a nation at war are in my keeping, for I guard the lines that unite the continent. I am a part of every plane that flies and every ship that sails the seas, for without long distance calls they could not have been built.

My job is one of the most important war jobs in the world. My responsibility is great, but my pride in it is greater, for, although I am unseen and unknown, I fight at my switchboard with the spirit of my brother with the gun.

By Patricia MacGill, evening toll operator, Miami, Fla.



A DOZEN telephone conversations at one time may leap across the mouth of Chesapeake Bay, instead of pursuing the circuitous route of the solid line, thanks to the application of carrier techniques to radio telephony

Type-K Carrier Techniques as Applied to Radio Telephony Provide Additional Circuits into an Important Region and Illustrate Another Advance in the Telephone Art

A Bridge for Speech across Chesapeake Bay

Austin Bailey

A BEE LINE between the towns of East Ocean View and Cape Charles, Va., across Chesapeake Bay near its mouth, is only twenty-five miles. And as the bee, so do telephone conversations now fly across that stretch of water: straight, and through the air. For since late in 1941 a unique radio system has spanned these waters. By means of this new speech bridge, telephone conversations can now go back and forth across, instead of more than four hundred miles around, Chesapeake Bay. Not only does the radio link shorten this telephone path, but it provides additional toll circuits into this Middle Atlantic seaboard region.

To the communications engineer, however, the significance of this radio link is not alone in the substitution of a 25-mile radio bridge for a 400-mile land route. It is in the character and performance of the link itself; for it represents an unusual illustration of the telephone art's development—a system that adapts the "carrier" technique to radio and provides twelve talking channels in a single radio frequency band.

More than a decade ago, engineers of the Bell System were considering ways to span the barrier of Chesapeake Bay with telephone circuits along the Atlantic Coast. Consideration was given to both submarine cable and radio as a means for doing this. Either way would be expensive, and each offered certain advantages. Tides, winds, and dragging anchors were some of the hazards to be reckoned with, as well as the vagaries of radio transmission. Moreover, it was fairly obvious at the beginning, from a knowledge of the region and the community of interest between the shores of the Bay, that a single voice channel would not adequately meet the demand for service. Several channels that could simultane-

ously carry telephone conversations would be needed—and of course this made the problem even more complex.

Complex the problem was, in its various aspects; but the answers were all found, and the system is working as the engineers planned. How the problem was solved is the subject-matter of the following pages.

strength of signals made possible more practical and more powerful radio telephone transmitters. This same kind of thing has taken place in many component parts and even in more complex systems and circuit arrangements, as the science of telephony has made its great strides during the past two decades or more.

Radio telephone systems from the

IN THIS BUILDING at Cape Charles are installed both the radio equipment and the equipment to convert 12 wire telephone channels into the single radio channel

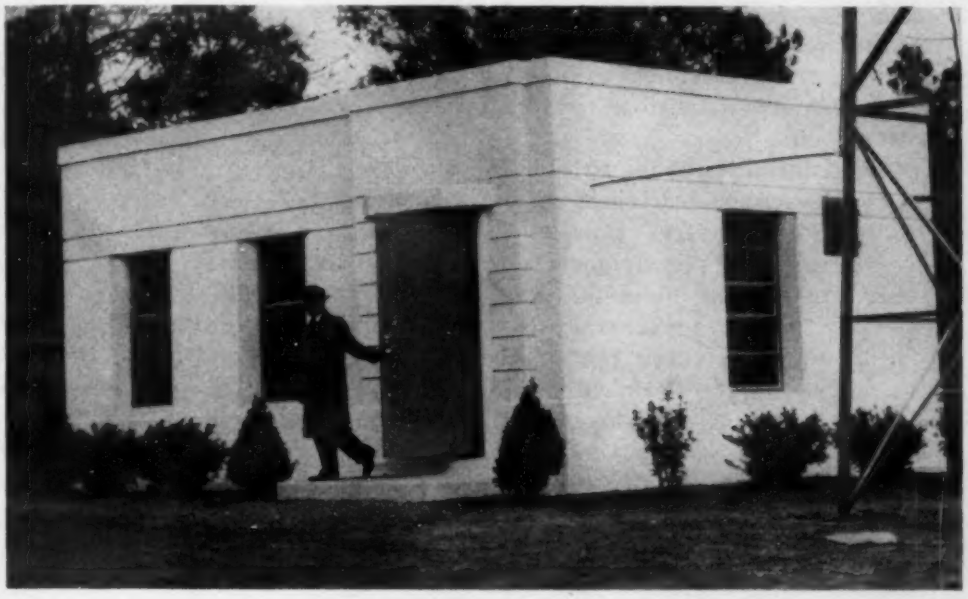
AN INTERPLAY between the allied telephone arts of transmission over wires and by radio has long been fruitful of progress to both. As an example, the vacuum tube, developed first as a radio detector, was improved and modified to become the "repeater" tube used in long wire circuits. And then the ability of this improved vacuum tube to increase the

first employed different frequencies, or bands, to separate individual stations. One could "tune in" this station or that by adjustment of the radio receiving device. The radio transmitters likewise were tuned to send their signals on certain frequencies, much as one tunes the strings of a musical instrument to sound certain notes of the musical scale. This

radio technique of separating channels for communication by "tuning" was applied to wire systems, and made possible multi-channel operation of the present-day "carrier" systems.

It is fairly obvious to us now, because of our own experience with radio broadcast receivers, that by means of "tuning," any one of a number of communication channels can be selected from the programs picked up by the antenna. In this way, then, a single wire circuit may have a number of communication bands sent into it, and at the other end these bands may be separated by "tuning"—as is actually done in carrier systems. Development has made it possible to put these bands very close together, and thus to transmit a number of them on a single wire circuit. These carrier systems are now extensively employed to obtain additional telephone channels over wires.

Among these carrier systems is one known as the Type K.* This system was first put into commercial use on telephone cables near the close of 1938. It is capable of transmitting twelve telephone conversations simultaneously without interference between them. It seemed that twelve telephone channels would be about the right number to provide for the immediate need for circuits across Chesapeake Bay and to allow for expected future growth. Consequently,



AT EAST OCEAN VIEW, on the lower side of the Bay, only the radio equipment is installed. The conversion equipment is housed in the Norfolk toll office

* See "Twenty Years of Carrier Telephony," BELL TELEPHONE QUARTERLY, October, 1938.

it was decided to undertake the development of a radio system that would be capable of transmitting all the bands of a Type-K cable carrier system as a single wide radio band.

Experience has taught those working with carrier transmission on wire lines that the step from an idea to an operating commercial system is not an easy one. There are many ramifications, such as special treatment of the wire circuits themselves to keep the carrier channels on the assigned paths, refined technique in building equipment, and greater loss in power which necessitates more closely spaced repeater points.

In much the same way, to put a number of telephone channels on a single radio transmitter simultaneously imposes new requirements on its design, to prevent interaction and interference between the several paths and to provide increased power to care for the greater band of frequencies transmitted. It was at first doubtful whether this could be done economically at all; but these problems were solved by Bell Telephone Laboratories engineers, and radio equipment was built which is capable of handling satisfactorily the output of Type-K cable carrier equipment.

How "Carrier" Works

IN ORDER to understand better what happens to a telephone band in the Type-K cable carrier system, reference should be made to Diagram A. The blocks lettered A to L inclusive represent bands of frequency space wide enough to transmit the frequencies ordinarily of importance in a telephone conversation. Each block represents, then, a telephone band. The position of each block across the top of the table represents its absolute frequency. As the telephone conversations arrive at the terminal of the Type-K cable carrier system over separate wire circuits, they all occupy the same frequency space. This is represented in the diagram by the pile of blocks on the corner of the table. The electrical equipment in the terminal converts each band to a new absolute frequency for transmission over the wire circuit. In the diagram, this is represented by putting each block on the table top in a line nearly side by side along the front, A′ to L′. These bands in this new arrangement can then be transmitted to the other end of the system and there again restored to the original frequency positions, to be distributed over separate wire circuits. This, in turn, would be shown in the diagram by pushing the blocks to the back of the table top for transmission over the line and by piling them up again on the left hand back corner for the frequency conversion that takes place in the receiving carrier terminal. By this process we have been able to push individual blocks to the back of the table all on one surface, while from the pile twelve shelves would have been needed to do this. This is analogous to the use of a single wire circuit instead of twelve to transmit the twelve telephone conversations.

In ordinary broadcasting, only one band or block of frequencies is used to control a single radio transmitter at any time. When the radio receiver is "tuned" to any particular position on the dial, in general only one program is heard. But there is really nothing very different physically between using a relatively narrow band

with a single program or a wider band with more than one. If the radio equipment were specially designed, we could either employ the block of frequencies represented by A in the diagram or a large block that would be represented by the space including A′ to L′ in the diagram. This latter is what was actually done for the equipment used to build the "speech bridge" across Chesapeake Bay.

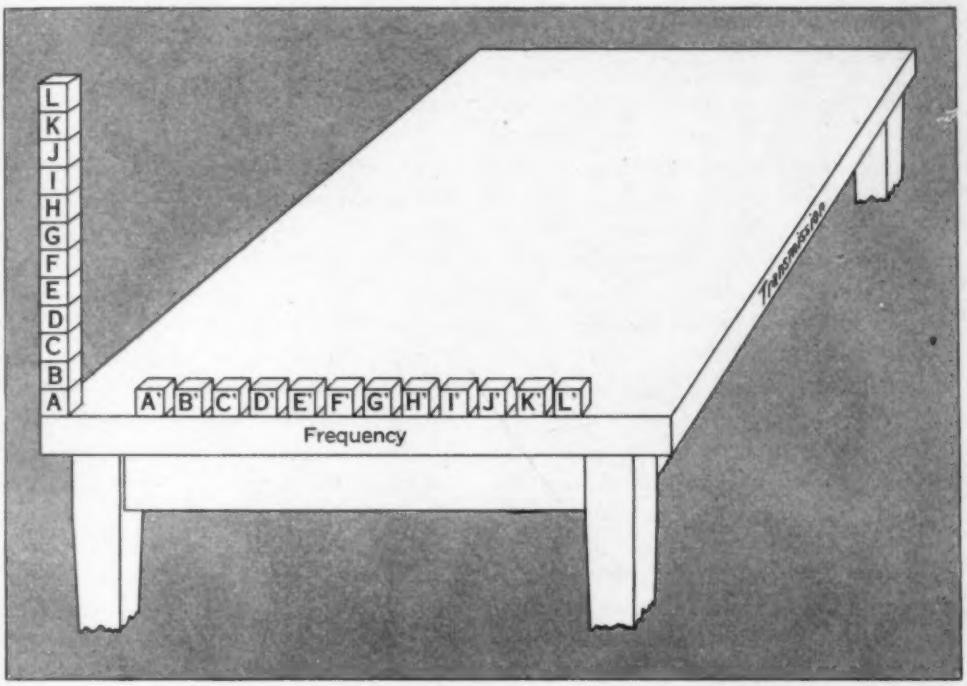


DIAGRAM A. Representing by analogy the frequency transformation and transmission of Type-K carrier channels, this diagram illustrates the explanation which begins on the opposite page

To obtain radio assignments with width great enough to accommodate the twelve telephone bands corresponding to the blocks A′ to L′ inclusive, it was necessary to employ very high frequencies, even higher than those now employed for FM (frequency modulation) broadcasting. A band in the very high frequency region was available, and the radio equipment was assigned to operate in this range. Furthermore, the special design included the ability to accept a group of telephone bands from the Type-K carrier system such as represented by blocks A′ to L′, extending from 12,000 to 60,000 cycles per second, and to control (or "modulate") the radio carrier with this group all at once. Currently, radio assignments in this region are on the basis of a band width of 150,000 cycles per second for a single communication channel, but by this system

twelve voice communication channels have been put into this same band width, representing an enormous conservation in the utilization of the channel space assigned from the radio spectrum.

STILL ANOTHER consequence following from the use of such very high frequencies is that very little noise from external sources affects the system. Man-made electrical disturbances in this region of the radio spectrum are exceedingly small, while static, even during an electrical storm, can be detected only infrequently. This generally low noise level reacts on the system design to make possible the use of less transmitting power than otherwise would be required.

The wave length in free space of the radio frequencies employed is about six feet. Such a small wave length has real advantages in designing antenna structures with high efficiency and directivity, because the parts can be close together and rigidly constructed.

These very high frequencies are propagated through space very much like light and obey essentially the same laws. From this it follows that the transmission path between the radio terminals should be substantially a path over which one terminal antenna could be seen from the other on a clear day. Limited only by the earth's curvature, a point 200 feet above the surface of the earth can be seen from a similar elevation about 35 miles distant. It is apparent, therefore, that the antennas at the two ends of the path across Chesapeake Bay—about twenty-five miles—could be less than two hundred feet in height.

With information of the nature outlined roughly above, but of course with scientific accuracy of detail, engineers of the Chesapeake and Potomac Telephone Company, the Bell Telephone Laboratories, the Western Electric Company, and the A. T. and T. Company devised a bridge for words to cross the waters of Chesapeake Bay. Near the town of Cape Charles, Virginia, land was acquired, a building constructed, and a steel tower erected. In the building was installed all of the equipment necessary to convert the twelve telephone channels into a single radio channel. At East Ocean View, about ten miles from Norfolk on the shore of Chesapeake Bay, similar work was accomplished, the building, however, being smaller because only radio equipment is installed at that location.

While this construction work was in progress in Virginia, the Laboratories and Western Electric were busily engaged in building and testing equipment units. Next came the period of installation and testing, first at one end, then at the other; and, finally, the over-all system from Norfolk to Cape Charles. Installed in the Norfolk toll office are the Type-K carrier equipment and system control and testing units. Such was the magnitude of the project that more than two years were required to complete the work.

How the System Works

PERHAPS a clearer picture of the whole wire, carrier, and radio system may be obtained from a simplified diagram of the relation between its more important components. Referring to Diagram B, suppose a telephone subscriber in Onancock or

Cape Charles wishes to talk with someone in the vicinity of Norfolk. He places the call just as he would a call to any other distant point. Following the usual operating method, the toll operator rings Norfolk on this newly established toll circuit, and passes the necessary details. Connection to the called telephone is established in the regular manner, and the conversation proceeds.

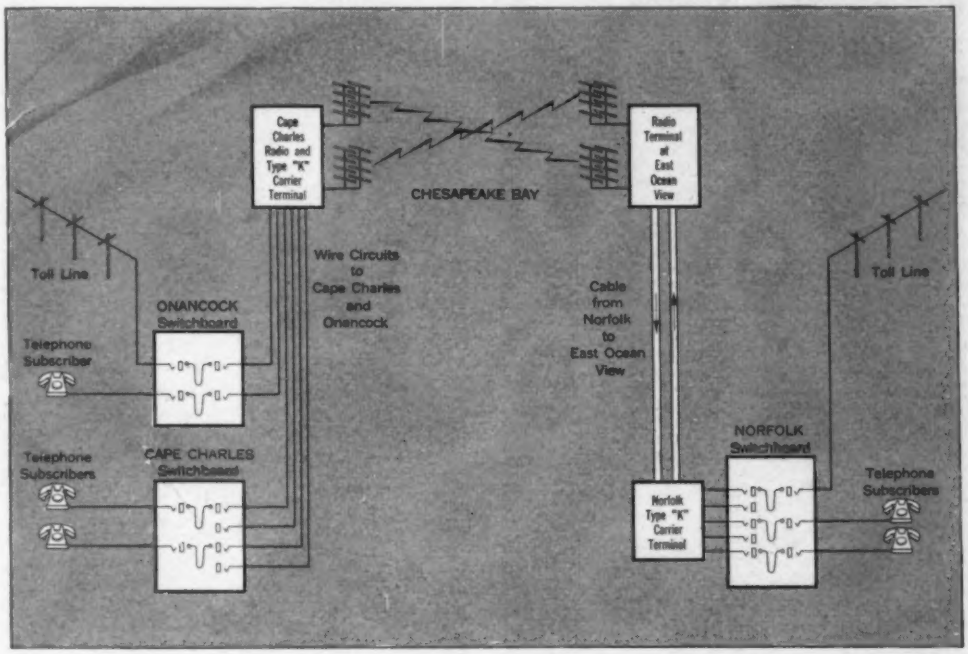


DIAGRAM B. The interrelation among the several parts of the system, as described in the accompanying text, is represented diagrammatically above

The subscriber at one end actuates one channel of the Type-K carrier terminal. This block of frequencies is then used to control the radio transmitter, and the radio waves are sent out across Chesapeake Bay to be received by the distant radio receiver tuned to accept the wide band which includes all such blocks. The individual block is then "tuned in" by the Type-K carrier equipment and changed back to the original absolute frequency to be transmitted over the wire circuit to the distant subscriber. The process in the reverse direction is much the same, the only significant difference being that in the radio part of the circuit a different radio frequency band is used to prevent the nearby radio receiver from picking up the local radio transmitter.

Each receiving Type-K carrier channel is definitely associated with a corresponding channel in the opposite direction to avoid any possibility of selecting the wrong return channel for any conversation. All the tuning

and selecting has been done once for all in the manufacturing of the equipment. The radio terminals are unattended.

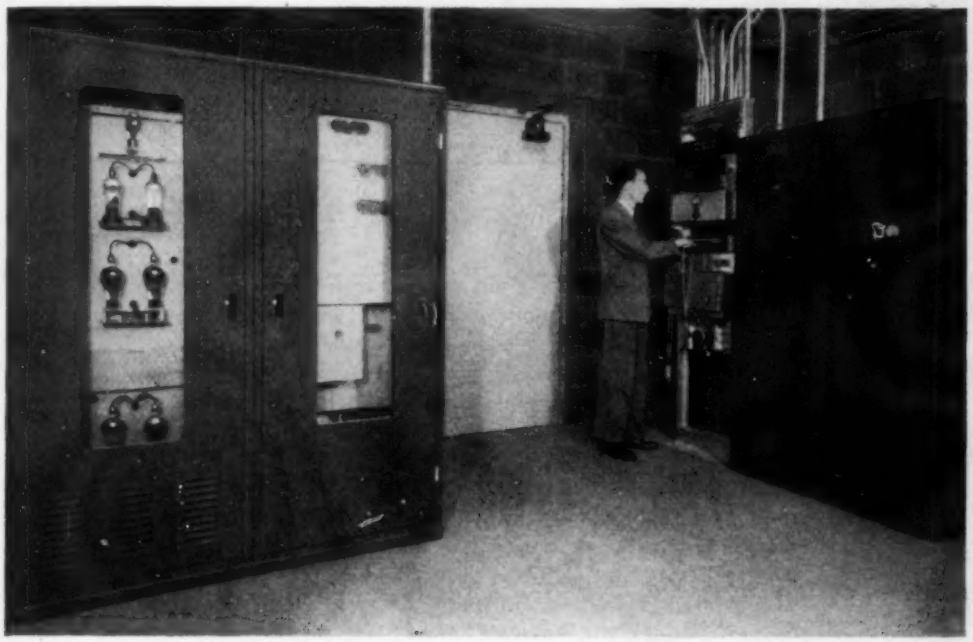
In addition to the circuit components indicated in the simplified diagram, remote control and testing facilities are provided in the Norfolk toll office which, by means of alarms, indicate any abnormal operation of the system. In case a failure should occur, the source of trouble can be quickly localized by the remote testing facilities provided, which enable, first, a determination of which terminal is at fault, and then whether the fault is in the sending or in the receiving path. The entire system is normally supplied with electricity from commercial sources; but, should there be an interruption of power at any of the stations, fully automatic emergency sources of power come into operation to restore the system to service.

As previously mentioned, the antennas are supported on steel towers slightly less than 200 feet in height.

PICTURED HERE is some of the testing and control equipment associated with the system. The author of this paper stands at the left

HERE THE voice currents from a dozen wire circuits are transformed for transmission on a single radio telephone circuit—and vice versa

Regulations of the Civil Aeronautics Administration require special painting and lighting on such tall structures because they may be hazardous to civilian air navigation. Under certain conditions, where such structures are strategically located, they may, if properly lighted, prove to be gasoline-driven engine alternator insure dependable operation. In recognition of the value of this beacon as an aid to air navigation, the Civil Aeronautics Administration has issued a certificate of "true light" to the Chesapeake and Potomac Telephone Company of Virginia.



INTERIOR of the East Ocean View station. At the right is the radio transmitter with its rectifier unit, and in the adjacent bay the line circuits and testing arrangements. At the left is the radio receiver. The fireproof door at the rear leads into a room housing the emergency power-supply apparatus

aids to air navigation. Because of the location of the tower at East Ocean View, the lighting on this tower was established in conformity with the national standards for a beacon light, and is operated nightly from before sunset to after sunrise. The emergency power facilities provided by an automatically operated

When the tests were finally completed and the system across Chesapeake Bay declared ready for service, it seemed desirable to break down this group of twelve circuits into several direct circuit links, in much the same way as would be done with the wire circuits in a telephone cable. All circuits terminate in Norfolk on

the south end; but to the north, five out of the nine which are assigned to general telephone service are terminated in Cape Charles and appear in the operator's switchboard at that point, while four circuits terminate in Onancock, which is the toll center for this Eastern Shore area.

TO THE telephone user, it makes no difference whether his conversation is over this radio bridge across the Chesapeake or by another route. The important thing is that, through such a span across a natural barrier, alternative routes become available whereby congested circuit conditions can be relieved and the reliability of communication by telephone can be further improved. Again the Bell System has put into service a new scientific achievement which makes possible through advances in the radio and carrier techniques a welding of the two, to provide a means for transmitting simultaneously as many as twelve telephone conversations across a barrier on a single radio channel.

"IF I WERE ASKED to cite specifically the document originally embodying the importance of this 'personnel' concept of public relations I should choose the A. T. & T. annual report for 1902. It reads: 'An essential obligation on the part of this company and the operating companies with which it is associated is to use every effort to give their patrons the best possible service. To do this the apparatus must be of the best design and quality, and must be installed under the most favorable conditions.' And here is the new thinking of 1902 which I ask you particularly to note: 'More than that,' the report goes on to say, 'the working force including not only the telephone operators who come into contact with the public, but all those upon whom is imposed the duty of keeping the apparatus in order and of arranging with the public for its use must be thoroughly trained, as well in the practical part of their work as in meeting and dealing properly with the public.' Here we see how forty years ago there began to emerge the recognition of employees—all employees—as valuable media for public relations. And today we see the results in the uniformly good reputation which the Bell System enjoys."

From an address, "Public Relations—the Reagent of Business," before the Advertising and Sales Executive Club of Montreal by Herbert H. Lank, Vice President, Canadian Industries.

Morse's First Telegraph Message, Dispatched a Hundred Years Ago, Began an Era of Faster and More Effective Ways of Sending the Written and the Spoken Word

A Century of Electrical Communication

Robertson T. Barrett

ON MAY 24, 1844, a small group of people was gathered around a table in a chamber of the United States Supreme Court at Washington. On the table rested what must have been, to them, a fascinating collection of apparatus. Over this bent a man of middle age—smooth-shaven, tall, lean almost to the point of gauntness, with deep-set eyes.

Glancing at a slip of paper which he held in one hand, he reached with the other toward the apparatus, or part of it. His hand moved up and down. His audience heard a series of faint, almost indistinguishable clicks. There was a pause. Then from another part of the apparatus came a succession of louder, sharper clicks, as a stylus attached to the end of a moving lever marked a series of dots and dashes on a paper tape.

"There your are, Miss Ellsworth," one may imagine him saying, as he turned to a young woman by his side. "There is your message, transmitted to Baltimore and back again, just as you wrote it out—*'What hath God wrought!'*"

The man at the table, now smiling almost triumphantly, was Samuel F. B. Morse. The dots and dashes, faintly impressed upon the paper tape, had spelled out the first telegraph message ever transmitted by means of his invention over so long a line as that which, with funds appropriated by the United States government, he had built between Washing and Baltimore.

This scene, enacted just one hundred years ago, was more than an episode; it was an event. It marked the beginning of a new chapter in the long history of men's effort to send their thoughts, expressed in written or spoken words, swiftly and surely to places far distant. With it began the era of successful communication by electricity.

In the advancement of the communication art during the past eventful century, whether in the telegraph field or in that which is more particularly their own, those who provide America's telephone service may take pardonable pride. The history of the telegraph and the history of the telephone are both parts of the greater history of electrical communications.

MORSE had conceived the idea which ripened into the invention of the telegraph while returning from Europe in 1832. During the twelve years that separated this birth of the telegraph idea in the mind of Morse and its final fruition in success, he had experienced many bitter hours of discouragement. There were periods during which the grim facts seemed to counsel that he forget his invention and return to his career as an artist, in which he had achieved no small reputation. When such dark days came, Morse refused to believe the facts, and held firmly to his faith. Deeply religious, and something of a mystic, he clung to the belief that he was an instrument of divine will, and that some intervention of Providence would guide him out of every failure to final success.

Out of one such period of discouragement had come the selection of the scriptural words, from Numbers 23: 23, that made up the first telegraph message. Morse had succeeded, early in 1843, in having a bill introduced in Congress appropriating $30,000 for the construction of an experimental telegraph line. The bill passed the House by the narrow margin of 89 to 80. Morse went to Washington to watch its further progress, and to expedite it if he could. While in that city he renewed his friendship with his Yale classmate, Henry L. Ellsworth, Commissioner of Patents, who, with the members of his family, strove to help and encourage the inventor.

Morse needed encouragement. Things were going badly with the telegraph bill in the Senate, which delayed action as the legislative session drew toward its close, on March 3. All through the weary hours of that day the inventor sat in the Senate Chamber, watching and hoping against hope as the proceedings dragged on. There were more than 140 pieces of proposed legislation to be acted on before his could be reached.

He asked two senatorial friends what the prospects were for the passage of his bill. Later he wrote: "Their answers were discouraging, and their advice was to prepare myself for disappointment. In this state of mind I retired to my chamber and made all arrangements for leaving Washington the next day."

A Joyous Surprise

THE NEXT MORNING, while at breakfast, he was surprised at the announcement of a waiter that a young woman wished to speak with him. He was greeted by the smiling face of Miss Annie Ellsworth, daughter of his friend the Commissioner of Patents. To his surprise, she said:

"I have come to congratulate you."

"Indeed, for what?" asked the perplexed Morse.

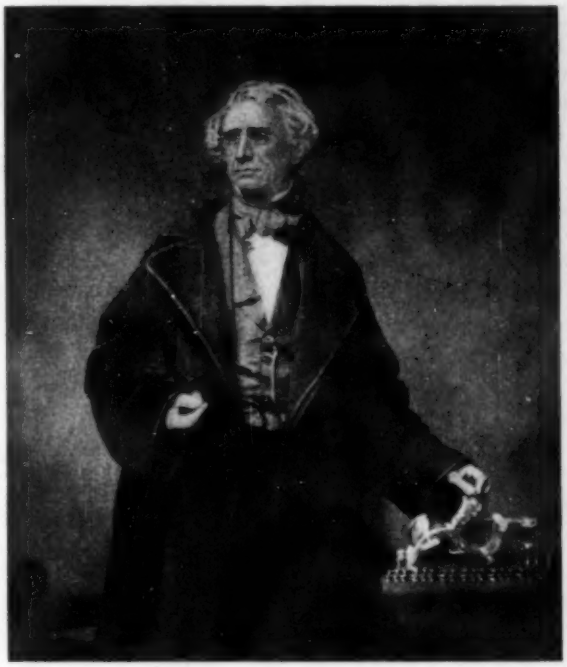
"On the passage of your bill," was the girl's beaming reply.

It was difficult for Miss Ellsworth to convince Morse that what she had

told him was true. Finally he said "You are the first to inform me, and now I am going to make you a promise: the first dispatch on the completed line shall be yours."

More than a year was occupied in the construction of the line, but he did not forget his promise. The words selected by Miss Ellsworth for the dispatch, as has been said, were: "What hath God wrought!" In his hour of success, following twelve years of disappointment and apparent failure, they must have seemed particularly appropriate to Morse. His was a faith, not alone in himself and in the soundness of his idea, but in the possibility of divine intervention in the affairs of men, to bring about what the facts had repeatedly said was impossible.

Morse must have had an equally firm faith that events would prove that there was a need for his invention—as they were to do. This moment of success could hardly have been timed more fortunately. The era was ripe for some new and swifter form of communication. National necessities demanded it. During the next century, these necessities were to become more and more urgent, and would demand still more effective means of speeding the written word, and the spoken word as well.



Sam'l F. B. Morse

Some of these needs were eco-

nomic. The pressure of population was accelerating the pace of the conquest of the continent. For all except the most conservative, life along the eastern seaboard was becoming too crowded. Men wanted elbow-room, and sought it in the West. They traveled. Little bands, at first, and then great caravans, began to make the long journey across plains and mountains. Within a few years after Morse tapped out his famous four-word message, a man was to find, in a California creek bed, a nugget of gold. The slow march of the settlers became literally the rush of frenzied feet. On the heels of trappers and missionaries who had blazed trails toward the setting sun came the "Forty-niners." Men were being pulled westward by the hope of new opportunities as well as pushed westward by the pressure of rapidly increasing population.

The Westward Urge

As POPULATION in the East became more concentrated, moreover, men had to send farther and farther for life's necessities. Railroads, over which a few locomotives were puffing uncertainly when Morse conceived his telegraph idea, grew apace. Each mile of track that was built was an answer to a growing need for swifter means of transportation, not only for passengers and goods, but for men's written messages. Postal service was improved, speeded up, and extended in reach. A new nation was growing up into maturity—and one of the evidences of its growth was something very like "growing pains." The time was coming when not even the railroad would provide communication swift enough to keep pace with the requirements of an economic machinery geared to high speed.

Certain social aspects there were, as well as those which were purely economic, in the nation's need for better and swifter communication facilities. To be sure, the telegraph was not, in its early stages of development, and is not now, employed extensively for social purposes—in the narrower meaning of that term. In a broader sense, it was and is a potent social factor. It permits the transmission of thought and intelligence, the interchange of ideas and opinions, which help men to understand each other better, and thus to live together more happily. It paved the way for other forms of electrical communication which even more directly form a bond between individual and individual.

The need for such a bond was beginning to become manifest when the telegraph came into being. The pioneers who made their way into unsettled regions were willing to undergo all of the privations which the conquest of the continent involved—except one. Ready enough, and even eager, to leave their homes in the East, they were not willing, if they could help themselves, to sever completely the ties which bound them to their loved ones there. Back over the trails they sent letters, borne at first by any chance messenger who could be prevailed upon to carry them. Later these informal means of communication were supplanted by others, such as the Overland Mail and the Pony Express, which in turn gave way to the first transcontinental telegraph line. They were hard-living, hard-fighting folk, these pioneers who pressed westward, but there was

in them a well defined streak of sentiment. They might but rarely use the telegraph lines as a means of keeping in touch with their relatives and friends—but it gave them a sense of satisfaction to know that the lines were there to use, if they were needed. The necessities which brought the era of electrical communication into being were, in part, social necessities.

In Washington on May 24, 1844

In a democracy, economic and social relations are closely akin to those which are purely political. That the telegraph and, later, other forms of electrical communication for which it led the way, have had a bearing on the political development of the United States is so apparent that the truth need be hardly more than stated. Doubtless the United States would have had a history during the one hundred years that began on May 24, 1844, had there been no telegraph; but doubtless it would have been a far different history.

The twelve years during which Morse was working to perfect his invention and win recognition for it lay, roughly speaking, midway between two wars. The War of 1812 had quite clearly settled some questions which the Revolution had left unsolved—as, for example, the question of interference by foreign powers in the affairs of the new republic. The War between the States was to settle another question that was be-

coming acute when the telegraph was born—the question of just what was implied by calling the American nation "a more perfect union."

BEFORE the outbreak of the second of these two conflicts, the United States was to engage in the Mexican War, which was to add vast territories to those over which the American flag was flying. The Oregon country was to become indisputably an American possession. Thousands of miles separated these newly acquired regions from the East in general and from the seat of government at Washington in particular. Distance became in a new sense a factor in the success of the American experiment in democracy. If the Union was to be preserved, and to become a still "more perfect Union," this expanse of open prairie and these towering mountains must be bridged by better and swifter communication facilities. It was no mere coincidence that the first transcontinental telegraph line was completed during the first year of the War between the States. The part played by this coast-to-coast telegraph line, and by the other facilities for nation-wide communication which followed it, in promoting the political solidarity of the United States, was one whose importance is obvious to all who know even a little of American history.

In a somewhat similar manner, the development of electrical communication facilities has been a factor of far-reaching effect in shaping the course of the relations between the United States and its neighbor nations. Global distances began to shrink when in 1866 Cyrus W. Field came to the successful end of his adventure in laying cables of telegraph wires along the bottom of the Atlantic. When to the ocean telegraph cable the wireless telegraph and the radio telephone were added, the isolation which had been provided by wide stretches of open sea was swept away, for good or for ill. Used to build a better world, these far-flung systems for the transmission of thought may play a still more important rôle in history. Whether they will help to produce a better world will depend upon the use that is made of them. Certain it is that they have already produced a smaller world.

Celebrating the Opening of an Era

IN PAYING well-earned tribute to Morse's great achievement, then, the American people are this year doing more than commemorating the invention of a piece of apparatus; they are celebrating the opening of an era. As Morse sat in Washington and ticked off the four words of this first message, he did more than write those four words, meaningful though they were. He began the writing of a new chapter in communication history, and thus a new chapter in the age-old story of human relations.

Morse's honors were well deserved, but were not won by him single-handed. There were, it is true, long periods when he had to face discouragement and defeat almost unaided. But it seems almost certain that he might never have reached final success without the encouragement of Joseph Henry; the scientific advice of Professor Leonard D. Gale, of New York University; and the technical skill of Alfred Vail. Like many other

great inventions, the telegraph was the product of coöperative effort.

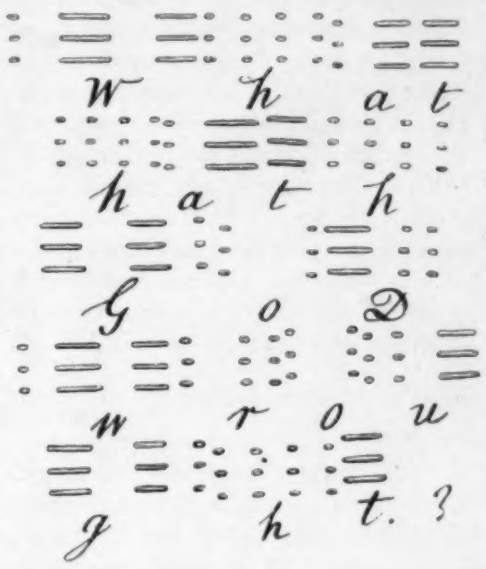
Nor was the idea of utilizing electricity for speeding men's messages new when Morse conceived his telegraph. Henry had perfected an efficient electro-magnet and, before Morse's eventful trip from Europe in 1832, had used it to ring a bell by means of a current transmitted over a considerable length of wire, which made his experimental apparatus, in effect, a potential telegraph system. Others, in Europe, notably Wheatstone and Cook in England, had developed telegraphs based on the fact that a needle can be deflected by changes in an electric current.

Nothing that was distinctly new, in itself, went into the invention of Morse's apparatus. To say which is not to detract from the greatness of his achievement. It is, rather, to pay high praise to his genius.

Artist and Inventor

IT MAY have been not altogether an accident that the telegraph was invented, not by a physicist who had spent years in the study of electricity, but by an artist. The genius of a great artist consists less in creating new things than in combining old and familiar things in new relations. When he surpasses his fellows, he does so in the skill with which he seizes commonplaces and unites them into creations of consummate beauty. It may have been the artist in Morse that led him to see, in what other men had produced in the field of electrical research, the separate elements which might be synthesized into the telegraph; that enabled him to visualize them in new relationships.

So, too, with the invention of the alphabet which bears his name, and which many students of the telegraph have pronounced a more noteworthy contribution to communication development than the telegraph itself. Men had been making short and long marks—dots and dashes—ever since the first caveman artist had traced on a piece of bone or on the walls of his dwelling a picture of a bison or some other familiar object. What the inventor of the telegraph code did was to arrange these dots and dashes in such a way as to give them new meaning. There is evidence that in working out this alphabet, Morse had a considerable amount of cooperation from Vail, as he did in perfecting his apparatus.



THE first telegraph message, as the receiving tape was cut and pasted in this form

As with its invention, so with the commercial development of the telegraph, success was the product of the

combined efforts of many men. Mention should perhaps be made of such men as Amos Kendall, whom Morse selected in 1843 as his agent in the promotion of his invention; Ezra Cornell, later to be widely known as a philanthropist and the founder of the university that bears his name; and Henry O'Reilly, who introduced the telegraph into New England and elsewhere. These were pathfinders in the promotion of the telegraph as a business and an instrumentality of public service in the early days. Later were to appear such figures as Hiram Sibley, of the Western Union Telegraph Company, and John W. Mackay, founder of the Postal Telegraph Company, which organizations were recently merged to form a single unified telegraph system, comparable in extent and in entity with America's nation-wide telephone system.

Telegraph and Telephone

ON JULY 26, 1874, thirty years after Morse's first telegraph message, Alexander Graham Bell explained to his father, at Brantford, Ontario, Canada, an idea he had conceived, presumably in Boston, for the electrical transmission of speech. The following year, on June 2, 1875, he verified his theory, and the first Bell telephone came from the skillful hands of his assistant, Thomas A. Watson. On March 10, 1876, the telephone transmitted its first complete sentence of speech. Somewhat less than two years later, the first commercial telephone exchange in the world was opened. A decade after the making of the first telephone, the first real step in the creation of a nation-wide system of long distance lines was taken with the organization, for that purpose, of the American Telephone and Telegraph Company.

With the growth, from these beginnings, of the nation-wide system of telephone lines which serves America today, the readers of the present article are presumably familiar. A detailed account of telephone development would have no place, even if space permitted, in a study which is devoted primarily to a discussion of Morse's great achievement, and what grew out of it.

For the telephone did not grow out of the telegraph. It was born in response to a need as urgent as that which brought the telegraph into being, but it was a different need. It was not intended to supplant the telegraph, has not done so, and seems unlikely ever to do so.

TELEGRAPH AND telephone supplement each other. Both were conceived and created in response to the needs of a nation and of a world. Both have been improved, have been made more efficient, have had their reach increased from year to year, as new conditions have made this necessary. Wireless telegraphy, which Marconi gave to the world when wire telegraphy was about a half a century old, was a new and improved form of what Morse had invented, and was brought into being to meet a new and intensified need. The radio telephone, similarly, was introduced in its first successful form to meet a need for facilities for communication by the spoken word where the use of physical circuits is impracticable.

These new needs have arisen out of the increasingly complex problems,

proceeding out of economic, social, and political growth, that were beginning to manifest themselves when Morse invented the telegraph. If some of these problems have been solved in America and in the world in any measure satisfactorily, no small part of the credit must be given to the far-reaching systems of electrical communication created during the past century. In the great problems which remain to be solved there is ground for hoping that these same communication facilities, more wisely used, will contribute importantly to their solution.

This much is clearly evident. As needs have arisen for ways of speeding more swiftly and surely men's written or spoken words, out of the workshops of solitary experimenters or the research laboratories of great communication companies have come the means of meeting these needs. Unless the spirit of the American people ceases to be what it is, the needs of the next century and those which follow it will be similarly met.

WHAT ARE Western's plans for FM? I am happy to say that we have nothing new to show you now and nothing new to talk about. I am happy because I do not have to tell a soldier named Joe, who needed a radio very badly last month, that we could not deliver it because we diverted some engineers and some shop people to building the model of a new super-dooper FM equipment to show you and thus strengthen our post-war position. I am sorry that I can't tell you when we will be able to talk. But then, no one can tell me when the war will be over.

From an address by F. R. Lack, Vice President, Western Electric Co., before a meeting of FM Broadcasters, Inc.

READERS of the Winter issue of this MAGAZINE who recall the article "Information about 'Information,'" and particularly the references to reducing the number of unnecessary calls to Information operators, may enjoy the following bit of dialogue from a recent "Duffy's Tavern" broadcast:

Colonel Stoopnagle—"Hello, Information, I'd like the phone number of Duffy's Tavern. . . ."

Archie—"But, Colonel, *this* is Duffy's Tavern!"

Stoopnagle—"Oh, really? What's the phone number?"

Archie—"It's Orchard 2–9970."

Stoopnagle—"Thank you. Hello, Information, that number is Orchard 2–9970. . . . You're welcome. . . . In the future, look it up in your directory."

The U. S. Army Is the Only Combatant Force Making Use of Frequency Modulation in Its Tactical Radio Sets in Armored Divisions and Field Artillery

Radio Telephones Guide the "Blitz Buggies"

Vance Hilliard

IT IS *D Day*—the day of the Allied invasion. The time is *H Hour plus 30*, or 30 minutes after the beginning of the powerful amphibious assault. In the second wave of landing craft to reach shore—*any* shore—is one which carries a particularly valuable cargo—a special radio car with olive-green paint and the white star of the U. S. Army on its sides. As the gate of the assault boat clatters down, the car moves into hub-deep water and across the beach to a place of concealment. Projecting above it is a slender antenna and in the rear seat is a new type of frequency modulated (FM) radio transmitter and receiver set.

As the car comes to a stop, the soldier seated at the radio begins to speak into the mouthpiece of the transmitter a succession of messages which may sound something like this: *"Mary-M to Kenneth . . . ready at B . . . will make contacts"; "Mary-M calling Green . . . in position . . . report . . . over"*; and *"Mary-M relay to Kenneth . . . relay from Green . . . no opposition at four-dash-six . . . no opposition at four-dash-six."* As each message ends, the operator stops only long enough to depress one of the push buttons on the radio panel in front of him before resuming his cryptic phrases.

Soon this spot and others along the coast are lined with landing craft of every description. From them pour tanks, scout cars, personnel carriers, and motorized artillery which form quickly into groups on the beach and then head inland on their invasion missions. With each attacking force is at least one FM radio, and each set is adjusted to a different frequency to eliminate interference.

The groups of vehicles are soon widely scattered, but the plan of attack—timed to the split second—is carried out on schedule. As objectives are reached and won, command-

ing officers make their reports and receive further orders by radio. Focus of all these messages is "Mary-M"—which may be the code name for the small radio station in the car at the beach. Using his FM transmitter-receiver as a relay station, the operator receives messages from the various forces inland and re-transmits them to invasion headquarters in a ship off-shore. When a group runs into unexpected opposition, "Mary-M" relays the information to others in the vicinity. When a landing beach is cleared, the signal is passed on by radio to the landing boats awaiting their turn.

As the invasion gathers momentum, messages come thick and fast, but the operator is able to shuttle them back and forth without losing a second of valuable time. His new combat radio equipment requires no manual tuning or hairline adjustments. It is operated by pushing buttons—not by turning dials and knobs—and it works almost automatically after the power is turned on. The set he is using is the "brain child" of engineers at the Bell Telephone Laboratories, designed by them in coöperation with the U. S. Army Signal Corps, and manufactured by the Western Electric Company.

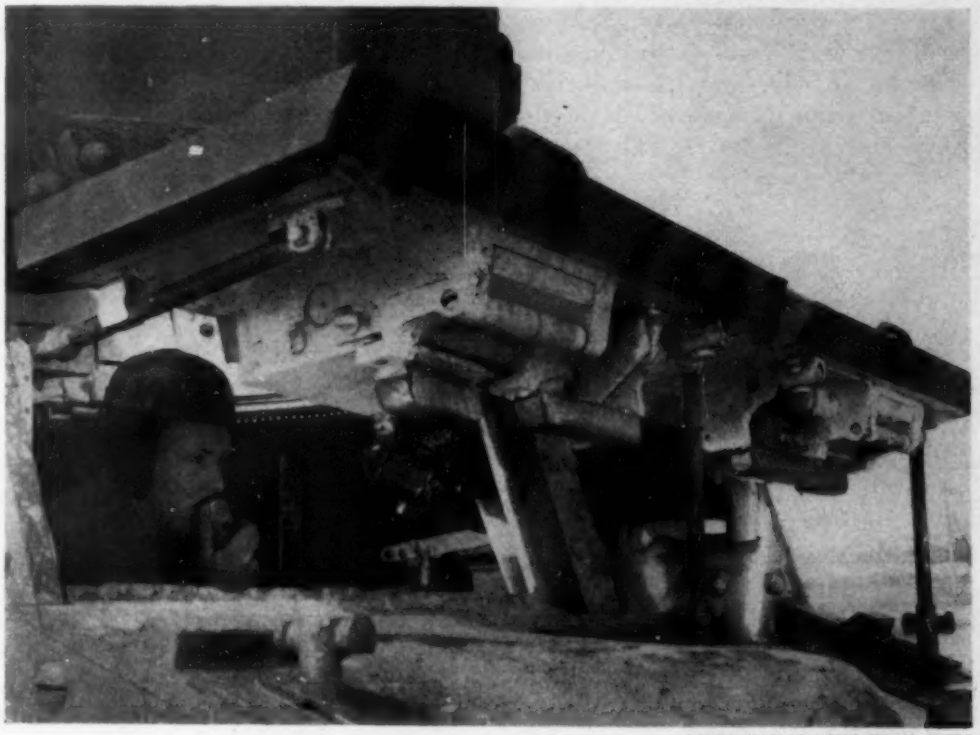


PHOTO BY U. S. ARMY SIGNAL CORPS

SOME OF THE radio telephone equipment which provides this American light tank's communications is faintly visible in the interior behind the driver

This radio equipment received its baptism under fire as described above at the Allied invasion of North Africa. Since that time it has been employed in the same way at our landings on the Sicilian beaches, at Salerno and Anzio in Italy, and in the South Pacific. When the long-awaited attack on "Fortress Europe" is a reality, the story will be repeated again and this new radio equipment will play an even more important part in coördinating the movements of our armored spearheads in their drive toward the heart of the enemy.*

"Gabriel" Under Fire

THE FIRST TYPE of FM combat radio developed by Bell Laboratories was the tank set. Later a slightly different unit, the FM field artillery set, was designed for that branch. The names are misleading, however, as both types of equipment are used throughout the armored divisions and field artillery in tanks, halftracks, tank destroyers, and command cars. Together they account for a sizeable percentage of all radio equipment installed in the vehicles of the U. S. Army—the only army in the world using frequency modulation in its tactical radio sets, according to the Signal Corps.

An indication of how a tank crew uses its radio when under fire can be gained from the story of a pitched tank battle reported from North Africa by a foreign correspondent for *Collier's* magazine.

A General Sherman tank, dubbed "Gabriel" by its crew, was on the extreme flank covering a withdrawal of our forces before Sbeitla. Exposed to German fire on three sides, its position was wholly unenviable. "Rusty" Fugate, Gabriel's commander, perched in the turret, saw dust in the distance. Then he saw tanks—Jerry tanks with five bogey wheels. He pushed a button on the radio transmitter beside him to get the frequency of the company commander's tank, and reported to Captain George Johnson that there were twenty enemy tanks in sight, more coming, and three had turned off to flank Gabriel's position.

"When do I fire, sir?" asked Fugate.

"Wait till they get even with you," said Johnson, "then pour it on."

The three German Mark IV's continued on their way, oblivious to Gabriel, then a good half-mile away. As they came parallel on the left, "Slim" Davis, the gunner, let them have it with his 75-mm. cannon. The resultant black explosion was 'way beyond the target. Frantic with fear that the quarry might escape, Slim made a correction for range and the next burst was right over the leading enemy tank. It disappeared in a mass of flames. The second shot accounted for another of the trio. The remaining tank was now backing off hastily and Slim's gun was tracking. A third shot—and a third blinding flash marked another hit!

WITH HIS RADIO on company frequency, Fugate reported, "We got all three, sir." Then, as he saw the third tank crawl painfully rearward, he added, disgustedly, "As you were! Only two, sir. One is getting away." Forgetting to switch his set from the transmitting position, and believing he was talking over the tank interphone system, he yelled at Slim for

* As this issue goes to press, the Allied invasion is still in preparation and not an actuality.

all to hear, "Are you gonna make a liar out of me now?"

Slim continued firing and explosions burst all around the crippled and retreating tank. After another blinding flash it flopped into a wadi and disappeared.

Then it came! Fugate heard a whistle and a scream, and ducked into the turret just as a shell exploded near Gabriel's stern. Still forgetting he was on the transmitting position, he shouted, "There goes home and Mother!"

The shell had just missed a direct hit and the tank was badly shaken. Looking around, Fugate saw that the main encounter between his buddies and the group of 37 German tanks had passed out of sight and Gabriel was all alone. Making contact with Captain Johnson again, he asked for orders, and was instructed to retreat slowly in a certain direction.

Gabriel found cover and limped back to join the others. On the trip home the company accounted for several German 88-mm. guns. A small explosive shell nicked Gabriel's rear sprocket, and 20-mm. machine gun slugs beat against its armor plate. Finally the company of tanks got through and crawled wearily to an olive grove in the rear.

PHOTO BY U. S. ARMY SIGNAL CORPS

FIELD ARTILLERY SETS, such as the one installed in this command car, link forward observers with batteries in the rear

The Radio Network

RADIO COMMUNICATION is to our armored divisions what the telephone is to the infantry. In the latter branch, each field army has its own vast telephone system which reaches, principally by wire, from front line observers through numerous field command posts all the way to general staff headquarters. In every armored unit a radio network similarly speeds combat information from the most advanced platoon—smallest unit in this command—back as far as corps headquarters.

The platoon leader, with several tanks under his direction, has both an FM transmitter and an FM receiver, while other tanks in the platoon may have receivers only. Several platoon leaders report to a company commander, who usually has a transmitter and two receivers in his tank.

Company commanders, in turn, report by radio to the battalion commander, whose "office" in the field is a halftrack motor vehicle. He has two complete radio sets: one for FM radio telephone communication and another for code transmission. With these he issues orders to the battalion's service units, mortar platoon, and mobile artillery, and makes his reports to the divisional commander above him.

Divisional headquarters, further to the rear, is the highest echelon of the armored command. Here the divisional commander—usually a major general—uses radio to direct the hundreds of tanks and cars in his armored group. He has the same two types of radio equipment used at battalion headquarters, and with these he receives messages from the battalion heads, and transmits commands to the division's artillery, reconnaissance units, and supply and maintenance services. Over the FM radio telephone he reports to the corps commander above him, who directs all the ground fighting in the area.

This effective communications system is built around Western Electric's FM radios, which form a major part of the 975 sets used by an armored division. The U. S. Army now has thousands of tanks in action and many thousands more in reserve, *and nearly every one of these carries radio equipment furnished by the Western Electric Company.*

THE FIELD ARTILLERY—a branch of our forces respected and feared by every German and Jap fighter—employs FM radio as an important part of its fire control system. Ranging far ahead of every rifle and howitzer battery is an observer—usually the only member of the artillery team to see the target on which the guns are trained. Through the radio in his scout car he sends back information on the location and range of the enemy-held objective. Battery computors convert this data into degrees of azimuth and elevation, and pass it along to the gun crews by telephone. The first "ranging" shots are usually wide of the mark but in a matter of seconds the corrections radioed from the observer put the battery "on target." Then it is often only a matter of loading and firing until the target is destroyed.

German and Jap prisoners taken by American troops have repeatedly admitted our artillery fire to be the most accurate and concentrated they

have ever seen. Training, equipment, and dependable communications have all helped our gun crews establish this enviable reputation.

Two Types of Radios

THE VEHICULAR RADIOS Western Electric has been producing under Signal Corps contracts since October, 1941, are of two general types. The original set was the tank set, now issued to both armored forces and artillery. The use intended for the vehicle determines whether its radio equipment consists of a receiver alone, a transmitter and receiver, or a transmitter with two receivers. When only a receiver is used, a special amplifier is necessary for the tank's interphone system. In a medium tank the set is installed in the gun turret; in a light tank it is generally placed in the sponson near the driver.

On the control panel of each transmitter and receiver are ten push buttons, which take the place of the usual calibrated tuning dials. These represent ten different radio frequencies or "wave lengths," and are used for the same purpose as the push buttons found on some home radios. By depressing one of these buttons, the operator automatically "tunes" the transmitter or receiver to the frequency desired—and in a fraction of a second he can change the frequency and talk on a different radio channel.

Behind a cover on the front of the transmitter are ten small quartz wafers, each enclosed in a plastic case. These crystals determine the exact frequencies on which the set will operate, and keep it from interfering with other transmitters. A drawer in the cabinet contains 70 additional crystals, each one made for a different radio frequency. By plugging in any ten of these in the crystal compartment, the transmission band is changed completely.

A special mounting which holds the transmitter and receivers and secures them to the tank chassis is more important to the successful operation of the set than its appearance indicates. In a moving tank, lunging and bucking over rough ground and leveling trees as large as telephone poles, even the crew must wear helmets and heavy padding to avoid injury. An unpro-

TEN OF THESE tiny quartz crystals operate in each FM radio. In each tank set 70 more, and in each artillery set 110 more, are available to change bands

tected radio set would be quickly damaged, no matter how strong its parts and connections. The mounting which is used was designed by the Bell Laboratories and is furnished by Western Electric as a part of the equipment. With the help of a leading rubber company, a special absorbent pad was developed which provides the necessary protection and is unaffected by extreme temperatures. Used between the set and the tank frame, these prevent shocks and vibration from reaching the radio apparatus. To discover just how much punishment the radio and mounting can take, the Army conducted a test which subjected a medium tank to numerous hits from a 75-mm. antitank gun. Several of the powerful shells exploded within a few feet of the radio equipment, but when the set was tested, it performed as though nothing had happened.

To provide communication within the tank, each crewman has a microphone, a headset, and an interphone control box for switching from one line to another. The interphone system is part of the radio equipment, and amplification is secured through the radio transmitter. In the past the hand-held microphone has been used for both interphone and radio transmission, but many crews now prefer the throat and lip "mikes," which leave both hands free for driving and fighting.

SECOND of the two types of Western Electric vehicular radios is the field artillery set, a slight modification of the original tank set. It operates on a somewhat higher frequency band and has 120 crystals instead of the 80 in the tank set. It is used throughout the field artillery by battery observers and for general communications. To meet special conditions it has been installed in many tanks. Because its frequency band overlaps the band used by the tank set, the two may be adjusted for intercommunication.

Radio and telephone communications in the U. S. Army has made rapid strides in the nearly five years since Hitler raised the curtain on World War II. In no branch is the advance more marked than in the armored forces or the artillery, whose latest vehicular radios have just been described. Much of the credit for these powerful communication weapons belongs to the scientists and engineers of the Bell Telephone Laboratories who conceived and developed the original design, and to the men and women of Western Electric who have manufactured them in quantity. Here is the story of how these two groups coöperated to produce a new and better type of combat radio.

The Signal Corps Program

SEVERAL YEARS before our entry into war, the Signal Corps initiated a development program which has given our fighting men a communication system—and communication equipment—second to none. In the latter part of 1940, Bell Laboratories was handed one of the toughest development jobs on the list—vehicular radios for tanks and motorized equipment. The Signal Corps knew in general what it wanted in this equipment, but it placed on the shoulders of the Laboratories' people the responsibility for creating an entirely new type of mobile radio: one that could take the terrific abuses of tank

warfare in its stride and still transmit clear, intelligible voice messages with little or no attention from the operator. To insure prompt contact between stations, it was decided to use quartz crystals for controlling the set's many frequencies instead of relying on tuned electrical circuits. With some apprehension the Laboratories accepted the job, and a time schedule was set which made the engineers involved shudder.

AM vs. FM

FIRST EFFORTS were directed toward the design of a conventional amplitude modulated set. Then it was decided to change the design to one of frequency modulation in order to reduce natural and man-made static and to improve the operation and range of the equipment. The original AM design was continued, however, so that comparative tests of the two could be made.

Because so much depended on its outcome, quartz crystal research was given emphasis and Laboratories' engineers worked with production specialists of Western Electric on the problems involved in mass-producing these precise little pieces of quartz. When the final designs were tested and found satisfactory on every count, one of the most difficult problems had been solved.

As the job progressed, countless rough sketches of circuits and layouts were made. The best of these were selected by laboratory tests and complicated mathematical procedures, and hundreds of working drawings and schematics were prepared. Mechanical engineers were called in, for this "tank set" had to be a mechanical masterpiece, with a multitude of gears, cams, and moving parts. Materials engineers did their part by devising alternatives to replace the aluminum and copper which it was then recognized would become scarce, and by fitting the set for the rough handling and extremes of temperature it would have to undergo. The Signal Corps aided in the development by conducting numerous tests and checking the Laboratories' results. Hand-made models of both transmitter and receiver were completed and given a final laboratory check. In normal times, at least a year would have been

A TANK SET gets an inspection at Western Electric's Hawthorne Works. This is one of many tests given before the equipment is turned over to the Signal Corps

required for so complex a job as this. Actually, it was only *three months* from the time the Signal Corps made its request to the Laboratories until the first hand-made FM set was completed.

Passing the Tests

THE FIRST field test of the finished equipment was made by the Laboratories' engineers alone. Taking the new transmitter and receiver some distance outside New York, they put them through their paces—and the results were gratifying. Next the equipment was taken to Fort Monmouth, where it was tested and approved by the Signal Corps. The last and severest test was at Fort Knox, a headquarters camp for armored units. There the set was installed in a tank and put through a stiff road test, to see if it could "take it." It could—and did! Then quality of reception and range of the Laboratories' set were compared with two sets designed by other organizations. The Laboratories' set won "hands down." Next an enlisted man with no previous experience as a radio operator was given a few minutes' instruction and then turned loose alone with the equipment to send and receive a series of messages. He encountered no difficulty in any of the operations.

There was no question about the set being accepted by the armored command. It had performed so well that the officers accepted it without making a single major change. It was a good radio, but the army needed thousands of sets instead of just one—and in a hurry. Production in quantity was Western Electric's responsibility.

Western Electric wasted no time in getting the set into production. Even before a contract was received the job got under way at Hawthorne, where work was started on 100 sets. Some of these had already been completed when the first army contract for thousands of transmitters, receivers, and mountings was signed.

Even under pressure, tooling for a job of this size takes a lot of time, but the army could not wait. It set October 31, 1941, as the date for delivery of the first five production sets. This allowed but six months for securing machines and tools, training hundreds of men and women for the exacting work, procuring raw materials, and setting up complicated testing procedures. More than fifty Hawthorne engineers were assigned to the project and work went on day and night, with Bell Laboratories' men on hand to help when they were needed.

Problems in Quartz

AMONG THE many production problems encountered—and solved—were those in crystal manufacture. To save quartz, the crystals had been designed as small as possible, with the result that a half-dozen will fit on a postage stamp without overlapping. These had to be finished to microscopic accuracy, then the faces silver-plated and the connecting wires and mount attached. Soldering irons were too slow and clumsy, so tiny jigs were designed to hold the elements while a minute drop of solder is melted on each face of the wafer by a blast of hot air.

Although temperature control of the crystals is provided in the transmitter by heating coils and a thermo-

stat in the crystal compartment, it was the aim from the first to make the crystals themselves immune to extremes of heat and cold. This aim is reflected in one of the tests given the finished crystals, which subjects them to temperatures of — 40° F. in a dry ice compartment and + 158° F. in a heat chamber. If the frequency of the crystal under test varies by more than .02 per cent, it is rejected.

The first production goal was reached by the October 31st deadline, when the five sets requested by the army were delivered. Five weeks later, when the Japanese attack drew us into war, the army's vehicular radio sets were leaving Hawthorne in quantity.

As America's war industries expanded, shortages of raw materials called for ingenuity in redesigning numerous parts of the equipment without slowing up the program. In spite of this and other manufacturing "headaches," every contract has been completed on schedule. The quantity delivered by Western Electric during the past two-and-one-half years is not for publication, but the total number is enormous. Our "blitz buggies" have not had to wait for their radio equipment.

From the beginning, some of each of the principal component units have been subcontracted to several selected manufacturers, and with the assistance of Western Electric engineers

SOLDIER STUDENTS at the Bell Telephone Laboratories School for War Training run a test on the tank radio as part of their training in repair and maintenance of this equipment

these subcontractors reached a point where they could handle the entire load. In 1943, with production running smoothly at Hawthorne, it was decided that the Western should concentrate its efforts on other, more critical electronic items for the Army and Navy, and the manufacturing job for vehicular radios was shifted to the established subcontractors. At present, Western Electric serves as a prime contractor, furnishing a few of the more critical items and with the responsibility of assuring the quality of every set before it is turned over to the Signal Corps.

The Bell Telephone Laboratories School for War Training has given valuable assistance to the Signal Corps by providing instruction for many of the technicians needed to repair and maintain the vehicular radio equipment. More than 300 army personnel—officers and enlisted men—have attended the school in New York to learn the principles of frequency modulation and the circuits and operation of these particular sets. After receiving five weeks of intensive training, they have been sent to army camps in this country and overseas to work in repair depots and instruct other groups.

When the war is over and all combat information has been compiled and analyzed, the FM tank and artillery radios developed and produced by the research laboratories and the manufacturing arm of the Bell System will certainly be recognized as having contributed materially to the success of our land offensives.

Who's Who & What's What

(*Continued from page 3*)

lately, "The American Telephone Historical Library: 20 Years of Service," in the MAGAZINE for November, 1942. The portrait of Morse on page 45 is reproduced from "Samuel F. B. Morse: Letters and Journals," through the courtesy of Houghton Mifflin Company, publishers.

VANCE HILLIARD

HAVING MAJORED in advertising and marketing in college, VANCE HILLIARD'S first business experience was, quite naturally, with a New York advertising agency, where he wrote advertising copy for industrial clients and assisted in the editing of a monthly magazine for printers. From this work he went to a manufacturer of heavy machinery, where he had charge of writing and producing sales bulletins and catalogues. He joined the Public Relations Department of the Western Electric Company in 1941 as a writer of advertising and publicity copy.

Aid to Victory

TWO YEARS OF WAR have tested the Bell System's character and its capacity to serve the nation. Good telephone service is vital to victory and events have demanded the utmost efforts to insure that every war telephone need be met. The results have contributed to the extraordinary accomplishments of American industry and the progress of our fighting forces all over the world. Ships, planes, tanks and guns have been produced in vast quantities and men trained and equipped to win victories, with a speed which would hardly have been possible without swift and plentiful telephone communication.

The war achievement of America is based on the heritage of freedom that America is waging war to preserve. The things we are fighting for are the things that will enable us to win. Our system of freedom of private enterprise has outmatched the productive accomplishments of every other country in the world, and our telephone service meets the requirements of American industry, and heightens its pace, because the telephone industry itself has had the stimulus of freedom.

Imagination and initiative, thus encouraged, have created the incomparable communications plant of the Bell System and have brought about steady progress in the telephone art. Telephone men and women have learned to work skillfully together as a team; abilities of individuals have been recognized and supervisory and management positions have been filled from the ranks. This policy has built up the collective experience necessary to meet the emergency of war and to train the great numbers of younger people now serving in the Bell Telephone Army on the home front. The System has been able to expand its service because over the years it has been permitted, under regulation, to earn enough money to pay good wages and also to pay a reasonable return on the savings invested in the business, sufficient to attract the new capital needed to meet growing demands.

Above all, the complement of freedom is the sense of responsibility which telephone people call the spirit of service. In this war the spirit of service is the spirit of victory, and the men and women of the Bell System, in whom this spirit lives, may be relied on to do their utmost.

From the A. T. & T. Annual Report for 1943.

FINANCIALLY, the Bell System has not profited by the war. Earnings on investment have, except for the recent depression years, been the lowest on record, a period of more than forty years, and, in spite of a record-breaking volume of business, earnings for each of the past two years have, in percentage of revenue, been lower than in any previous year, not excepting the lowest of the depression years. Although the price of practically everything has increased, telephone rates have not increased:—on the contrary, long distance telephone rates have been reduced substantially. The schedules of pay of Bell System employees are the highest they have ever been.

Financially, the Bell System, while not itself profiting by the war, has contributed very substantially to the war effort. Since Pearl Harbor, the System has paid in taxes to the Federal Government more than $648,000,000, or nearly two-thirds of a billion dollars. Over $300,000,000 additional has been collected by Bell System companies and paid to the Federal Government in excise taxes borne directly by telephone users. Thus, about a billion dollars of the cost of the war has been paid directly and indirectly by the Bell System and its telephone customers. Moreover, the System has coöperated in each of the four War Loan campaigns and has kept practically all of its cash assets invested in Government securities. Also, some $200,000,000 of United States War Savings Bonds have been purchased by Bell System employees through payroll savings plans and in War Loan campaigns.

From President Walter S. Gifford's statement to A. T. & T. stockholders at the Annual Meeting on April 19.

For the Record

A selected list of happenings, of System interest, occurring between January 1 and April 30, 1944

TELEPHONE conservation order U-2 and preference rating order U-3 were slightly amended by WPB on January 20, the changes being in the direction of greater flexibility. On March 18 telephone limitation order U-8, a revision of order L-204, became effective, affecting the purchase of telephone parts and relaxing somewhat restrictions on production of special types of telephones. U-3 was further amended on March 15 and U-8 on April 7.

Assistant Secretary of State Adolf A. Berle was appointed to the Board of War Communications on February 1, succeeding Assistant Secretary of State Breckenridge Long. In preparation for the invasion of western Europe, BWC established on April 13 the offices of traffic coördinator and assistant traffic coördinator, naming to the former post Commander Franz O. Willenbucher, U.S.N., and to the latter Marion H. Woodward of the staff of the FCC.

Chief Engineer E. K. Jett of the FCC became a member of the Commission on February 15. He was succeeded as Chief Engineer by George P. Adair, who had been Assistant Chief Engineer in charge of broadcasting.

The Associated Companies of the Bell System filed tariffs with the FCC, effective February 15, to prohibit the collection by hotels, apartment houses, and clubs of surcharges on interstate and foreign long distance telephone messages. At the same time, the companies agreed to pay 15 per cent commissions to hotels, apartment houses, and clubs on charges for such messages from guest rooms.

Radio telephone service was officially opened between the United States and Trinidad, B. W. I., on February 23. On April 27 it was announced that restrictions on personal radio telephone calls between the U. S. and the Bahamas, Jamaica, and Trinidad were lifted and that important business as well as government calls between the U. S. and Bermuda may now be made.

In a letter to President Niles Trammel of the National Broadcasting Company dated February 29, Vice President K. S. McHugh of A. T. & T. Co. pointed out that the Bell System's planned construction of several thousand miles of coaxial cable within the next five years may form the basis of a nation-wide television network. On March 16 the A. T. & T. Co. announced its plans for the trial of short-wave relay radio between New York and Boston as a means of supplementing present long distance telephone facilities and of transmitting television programs.

Beginning on March 1, night message toll telephone rates became effective at 6 P. M. instead of 7 P. M. A reduction in overtime rates on most teletypewriter exchange service took effect at the same time. The former was expected to result in an annual reduction of about $8,250,000 and the latter about $2,450,000.

On April 1 the "anti-slug" bill, which makes the manufacture or sale of slugs for fraudulent purposes a felony, became federal law.

The annual meeting of stockholders of the A. T. & T. Co. was held on April 19. All 18 directors were re-elected.

The granting of the National Security Award, established to "recognize superior organization for plant protection and security," to all of the operating companies of the Bell System, including the Long Lines Department, was announced on April 20 by the U. S. Office of Civilian Defense.